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Gonzalez et al.

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(54) **ACCESS ARBITRATION MODULE AND SYSTEM FOR SEMICONDUCTOR FABRICATION EQUIPMENT AND METHODS FOR USING AND OPERATING THE SAME**

6,240,335 B1 5/2001 Wehrung et al.
6,502,869 B1 1/2003 Rosenquist et al.
2008/0126414 A1 5/2008 Parimi
2010/0279438 A1* 11/2010 An et al. 438/14
2012/0082063 A1* 4/2012 Fujita 370/255

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OTHER PUBLICATIONS

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Chapter 6 Integrated Optics. Koch et al. Handbooks of Optics, OSA(vol. I and vol. II). 1995.*

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International Search Report and Written Opinion of the International Search Authority/US for PCT App. No. PCT/US13/57728, Mailed Dec. 3, 2013.

* cited by examiner

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(57) **ABSTRACT**

(51) **Int. Cl.**
H01L 21/52 (2006.01)
G06F 21/44 (2013.01)
H01L 21/98 (2006.01)

An access arbitration module includes a plurality of active component communication ports for communicating with a plurality of active components, and includes a passive component communication port for communicating with a passive component. The access arbitration module also includes switching logic defined to control transmission of access communication protocol signals between each of the plurality of active component communication ports and the passive component communication port, such that an authorized one of the plurality of active component communication ports is connected in communication with the passive component communication port at a given time, and such that non-authorized ones of the plurality of active component communication ports are prevented from communication with the passive component communication port at the given time.

(52) **U.S. Cl.**
CPC **G06F 21/44** (2013.01)
USPC **726/26; 716/110; 716/137**

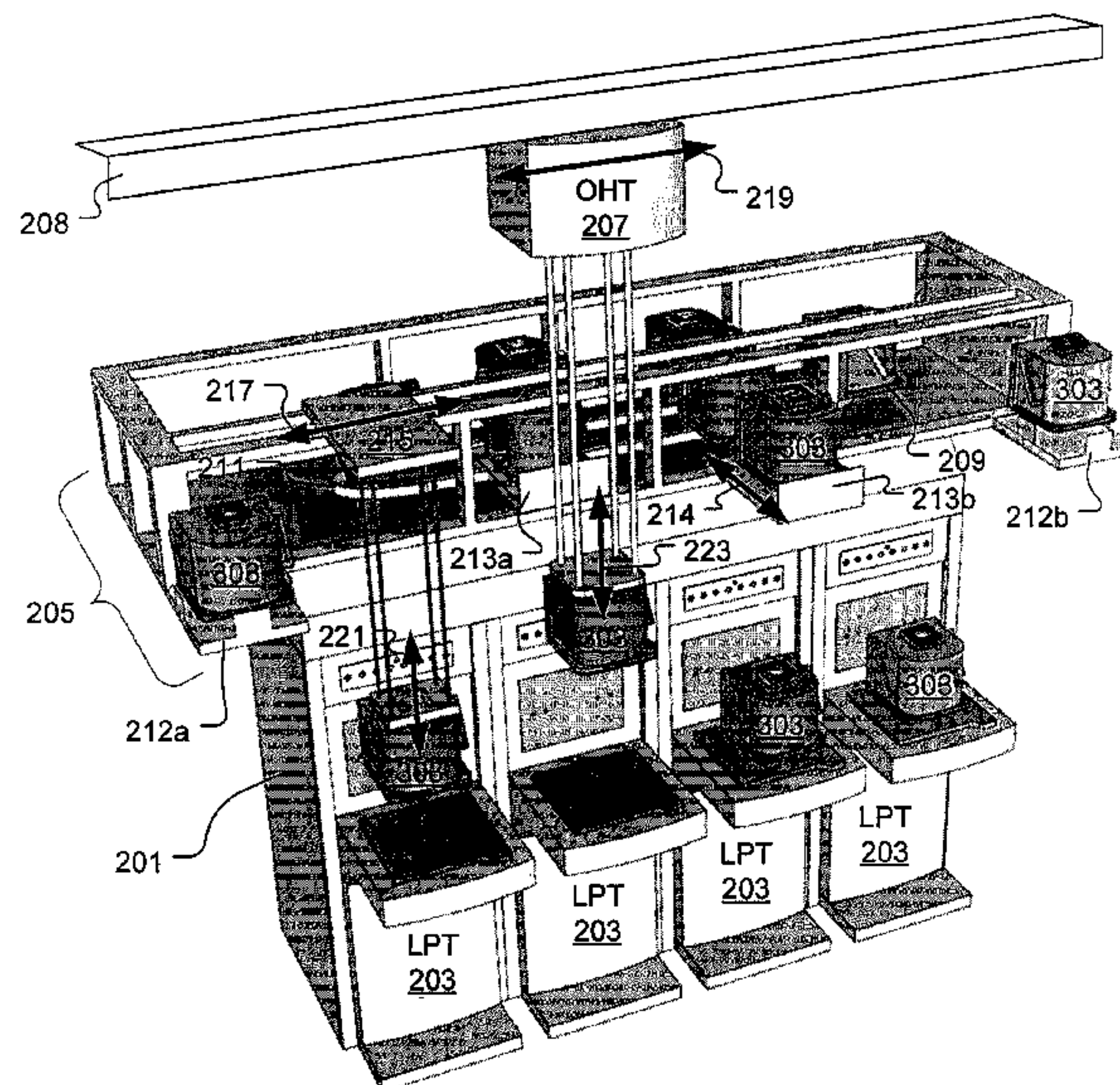
(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,995,430 A 2/1991 Bonora et al.
6,195,593 B1 2/2001 Nguyen

16 Claims, 13 Drawing Sheets



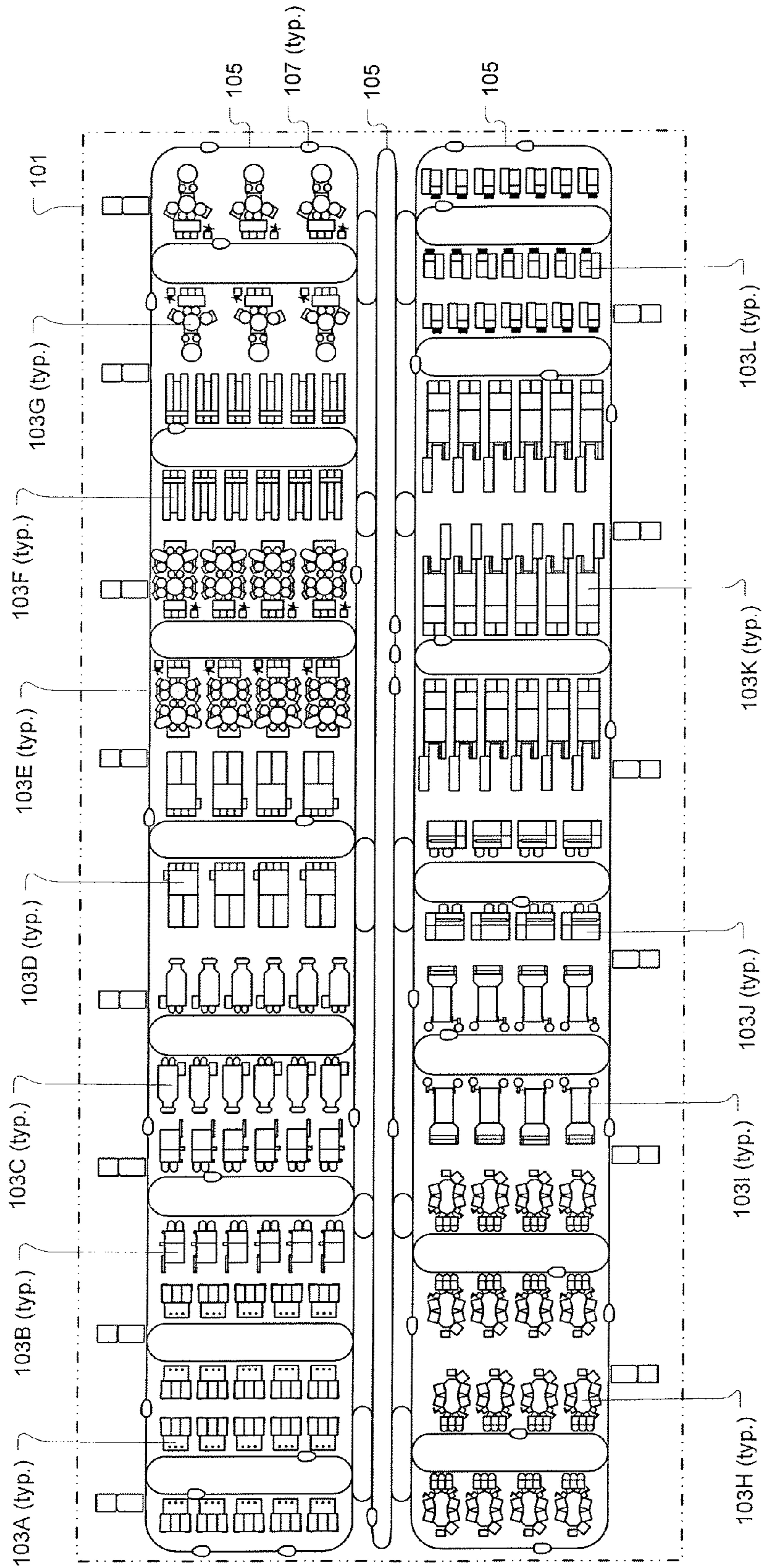


Fig. 1

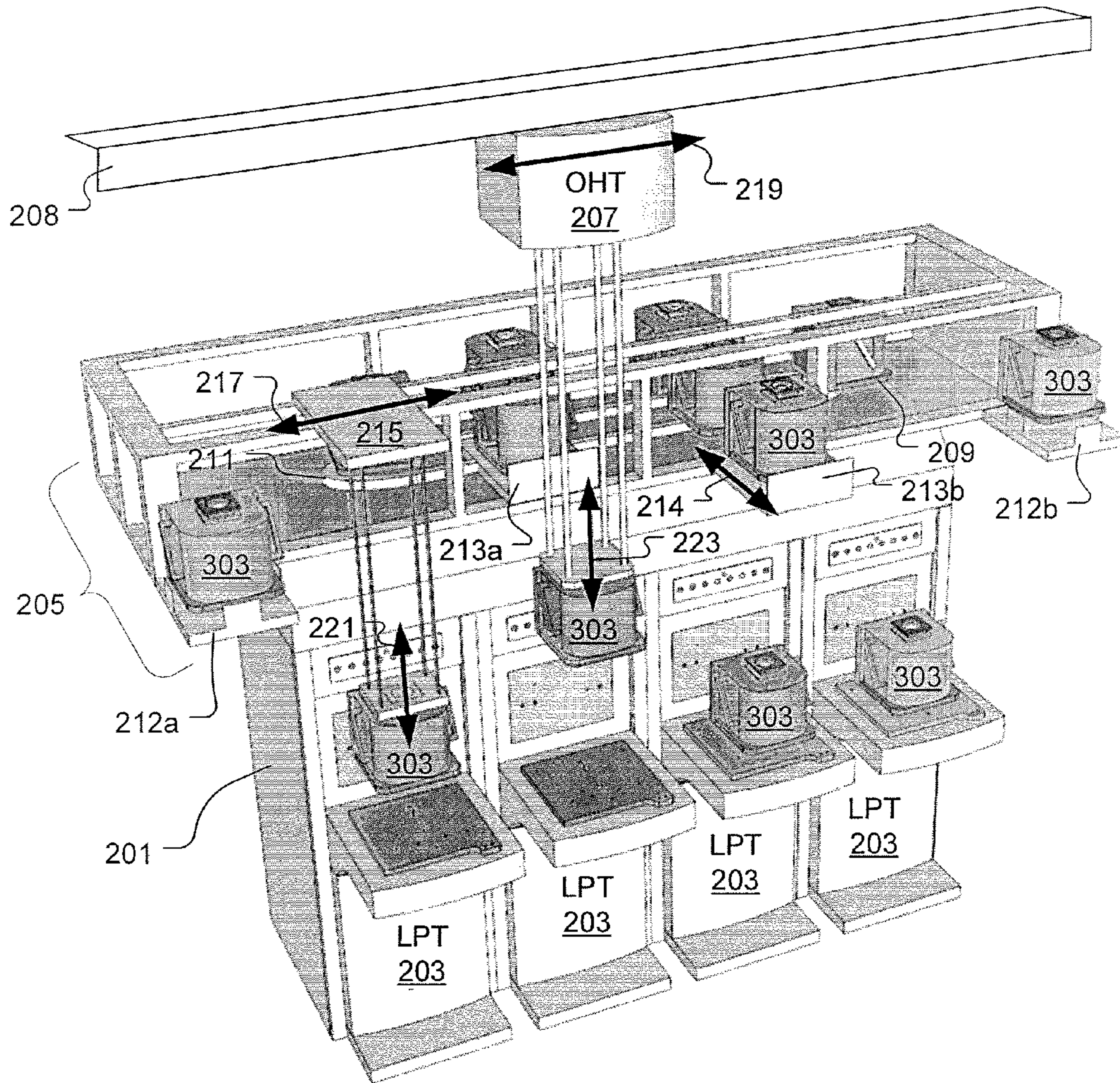


Fig. 2

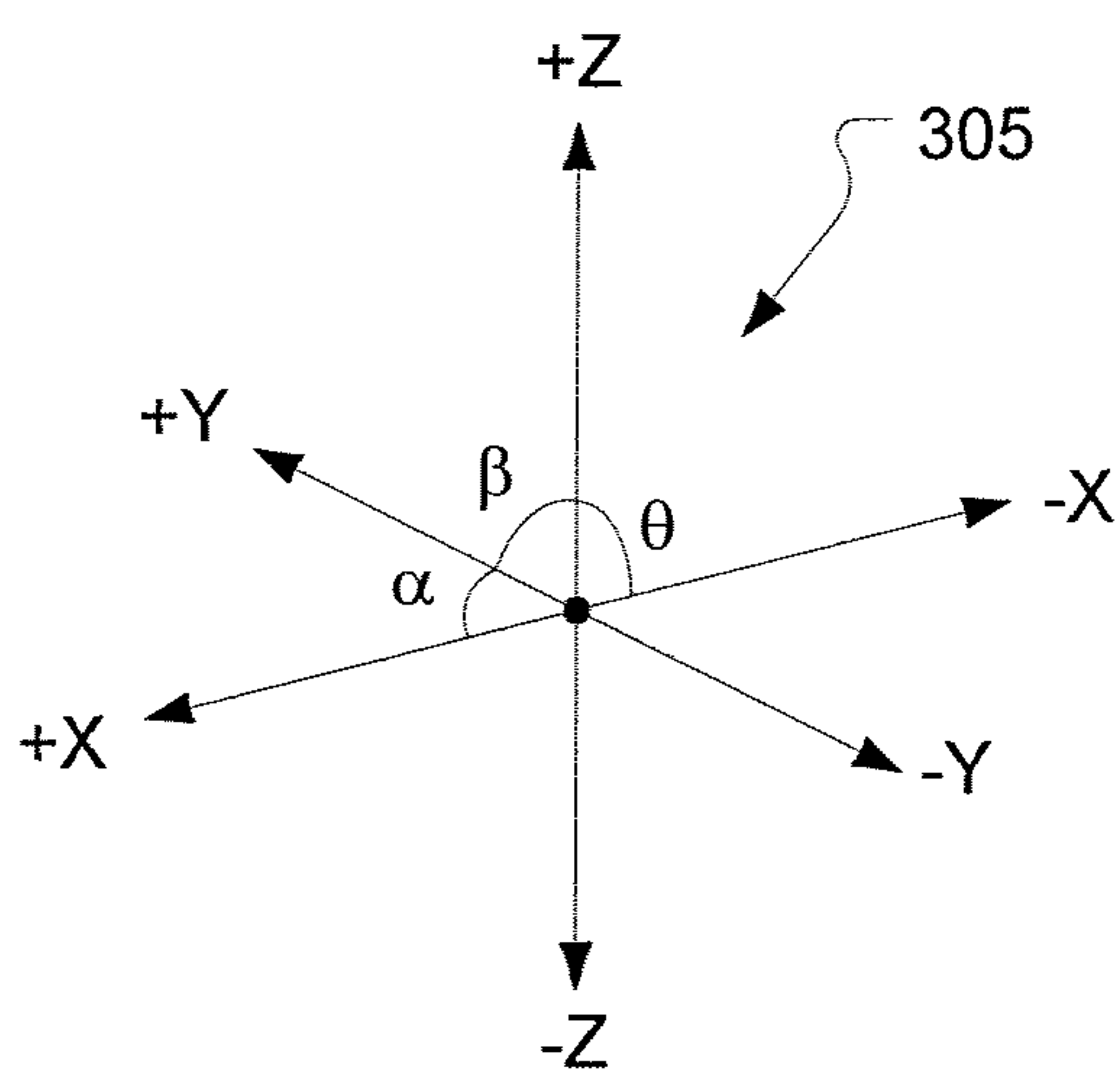
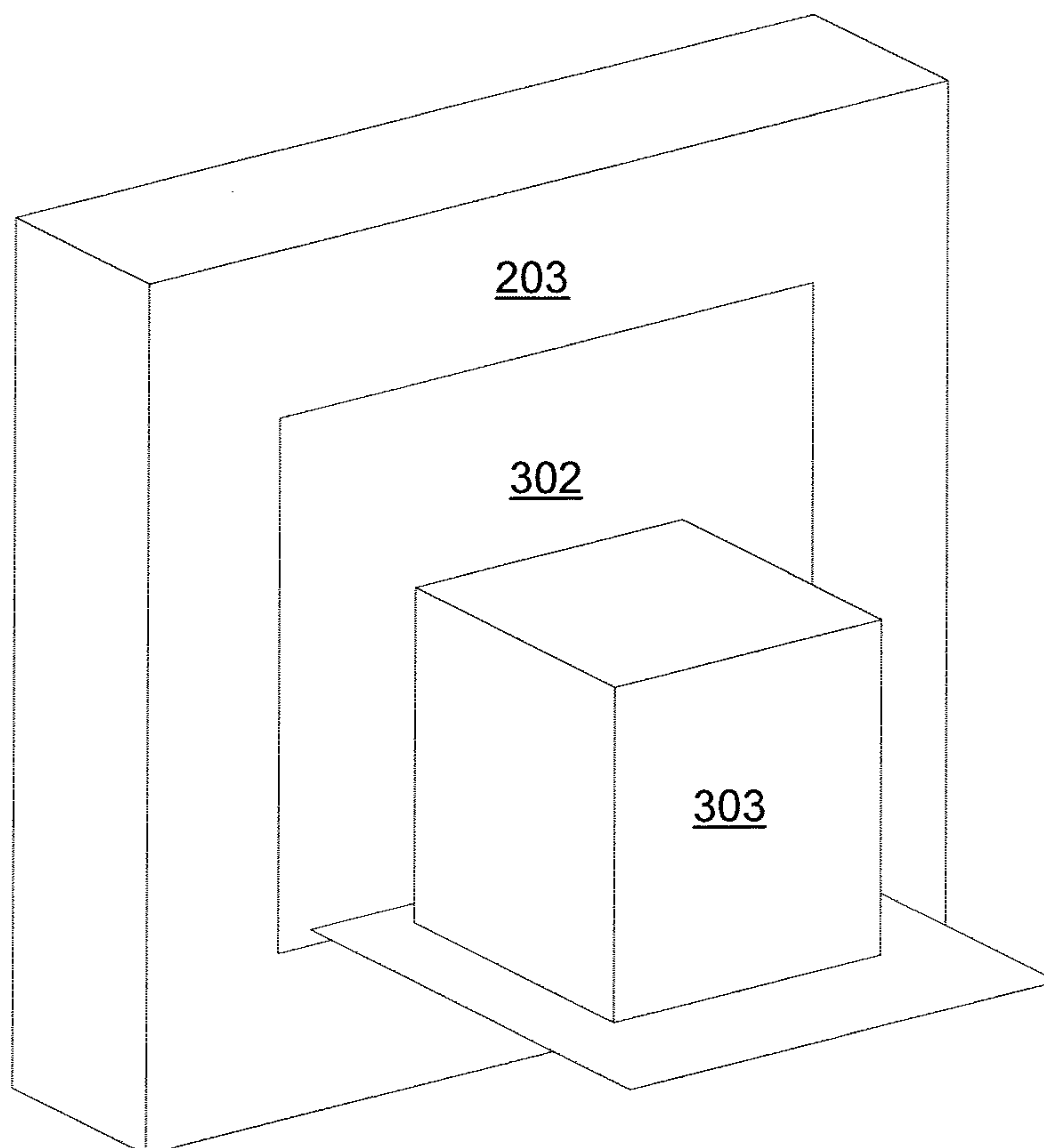


Fig. 3A

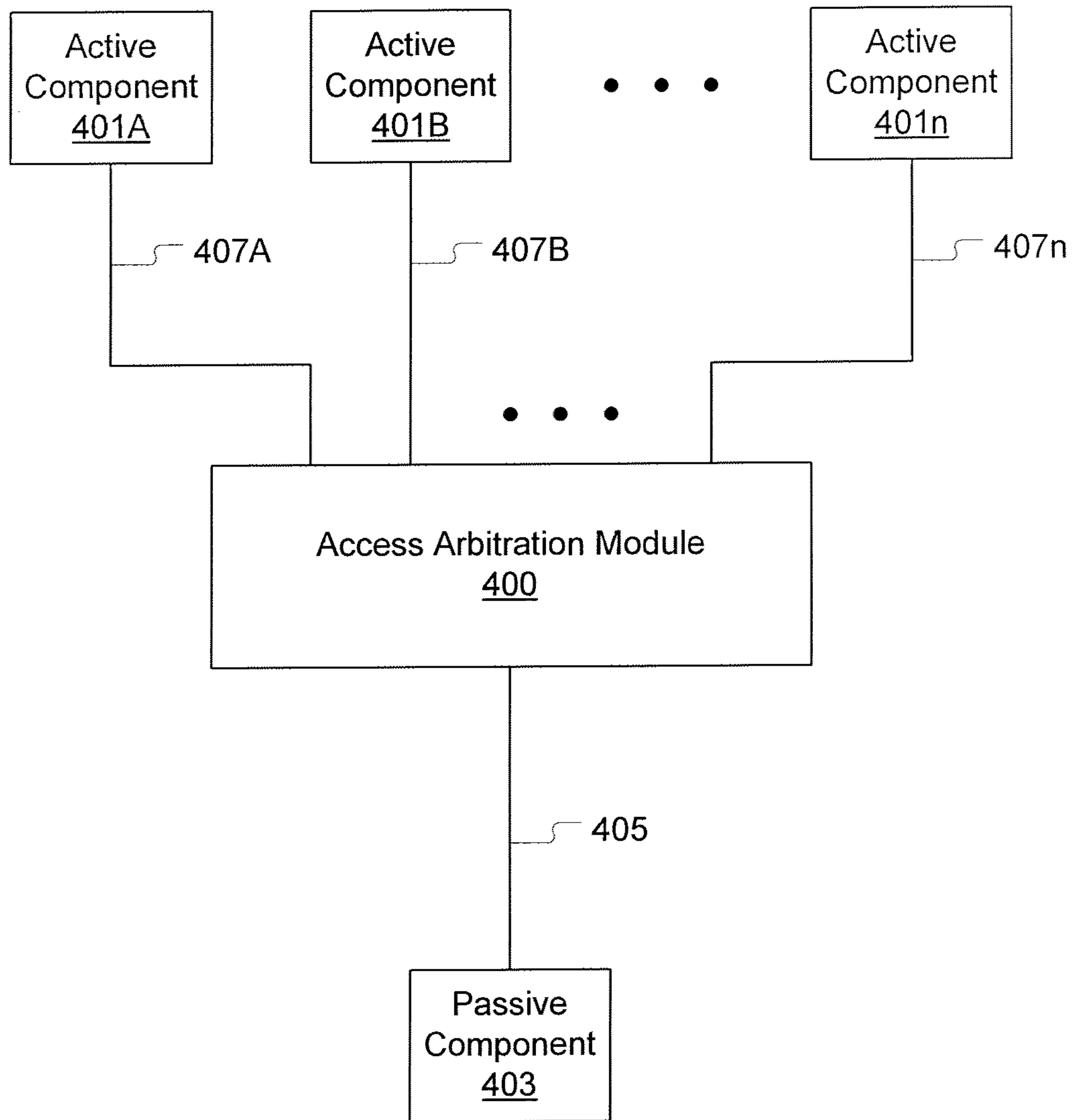


Fig. 4

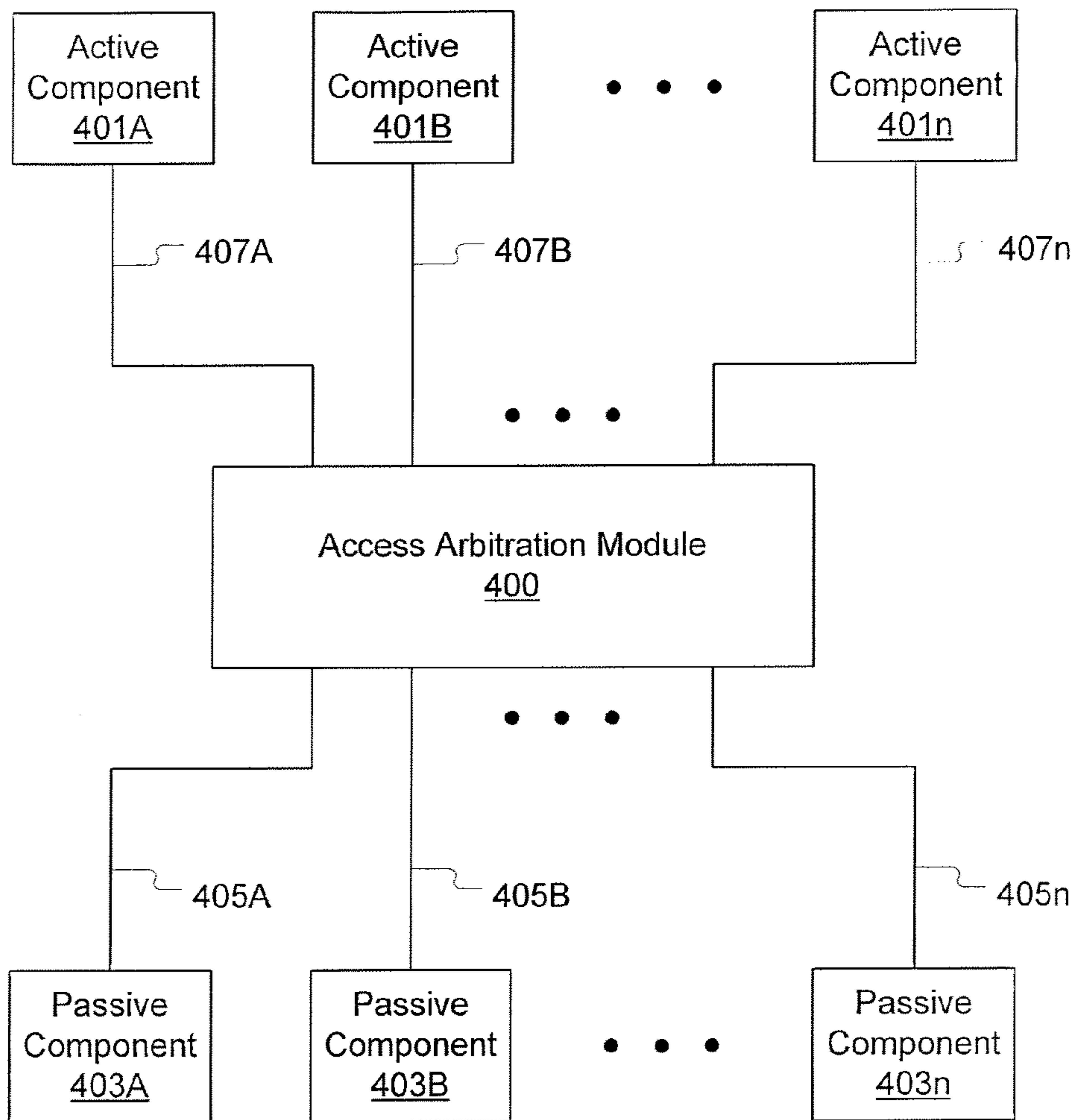


Fig. 5

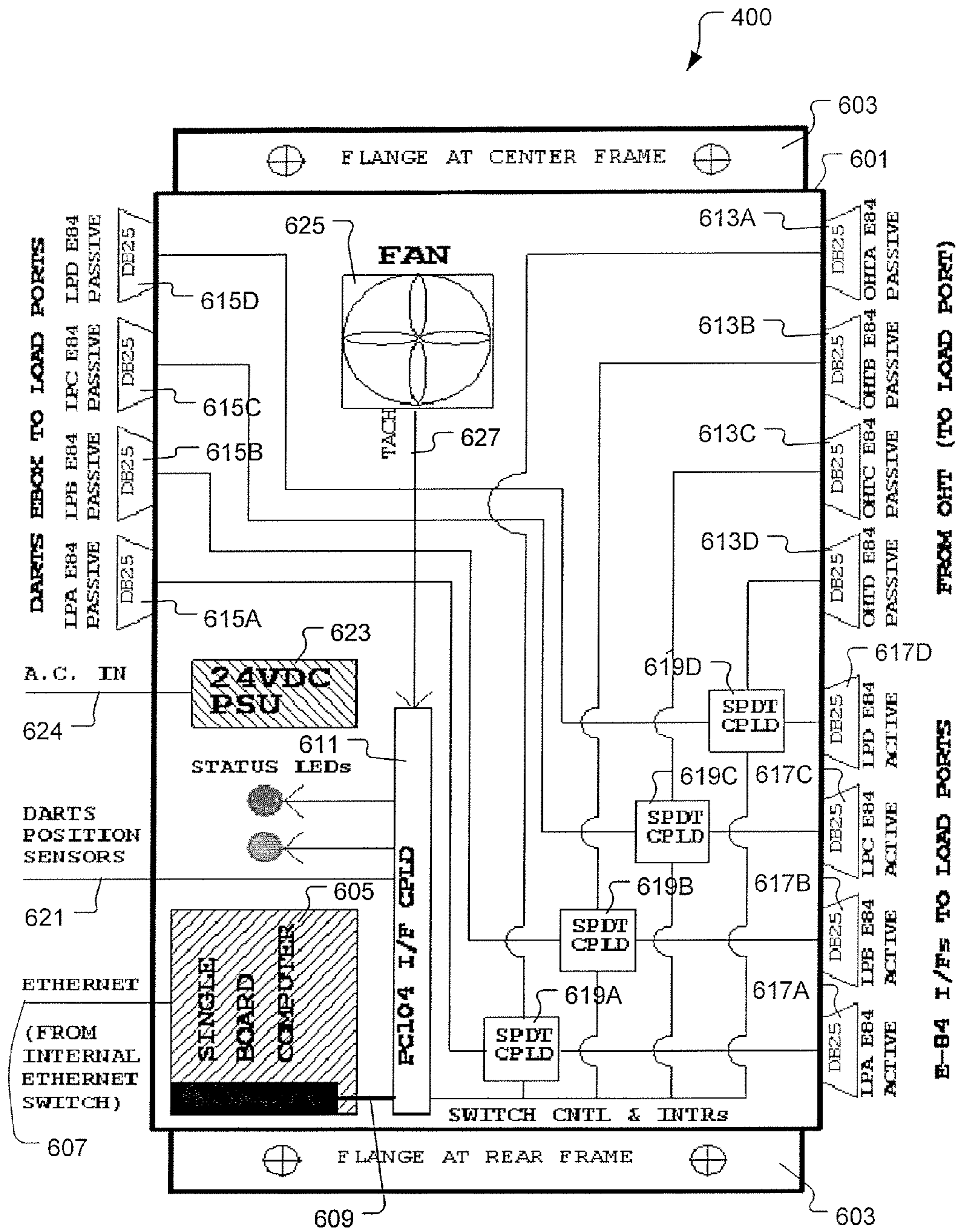


Fig. 6

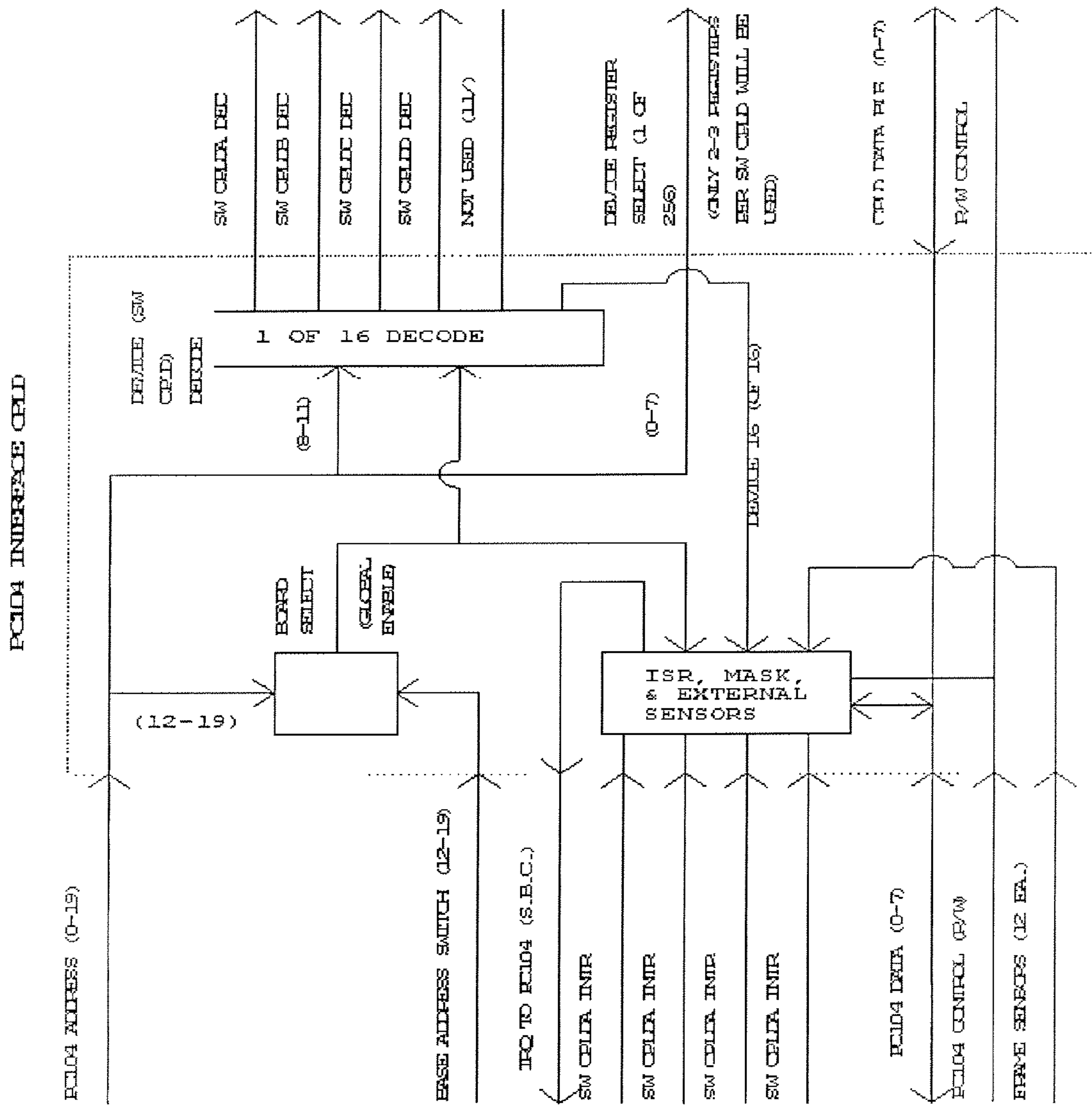


Fig. 7

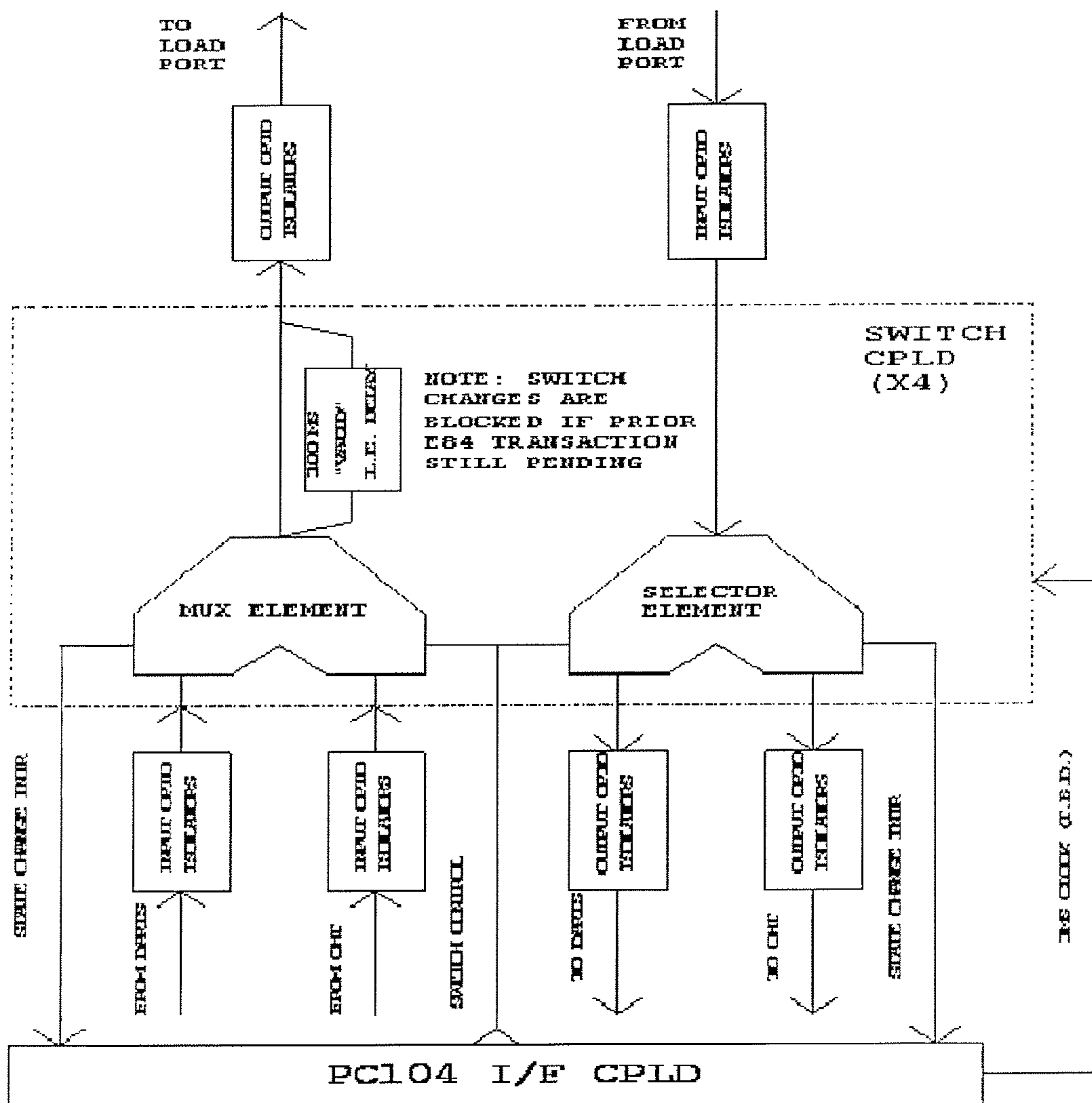


Fig. 8

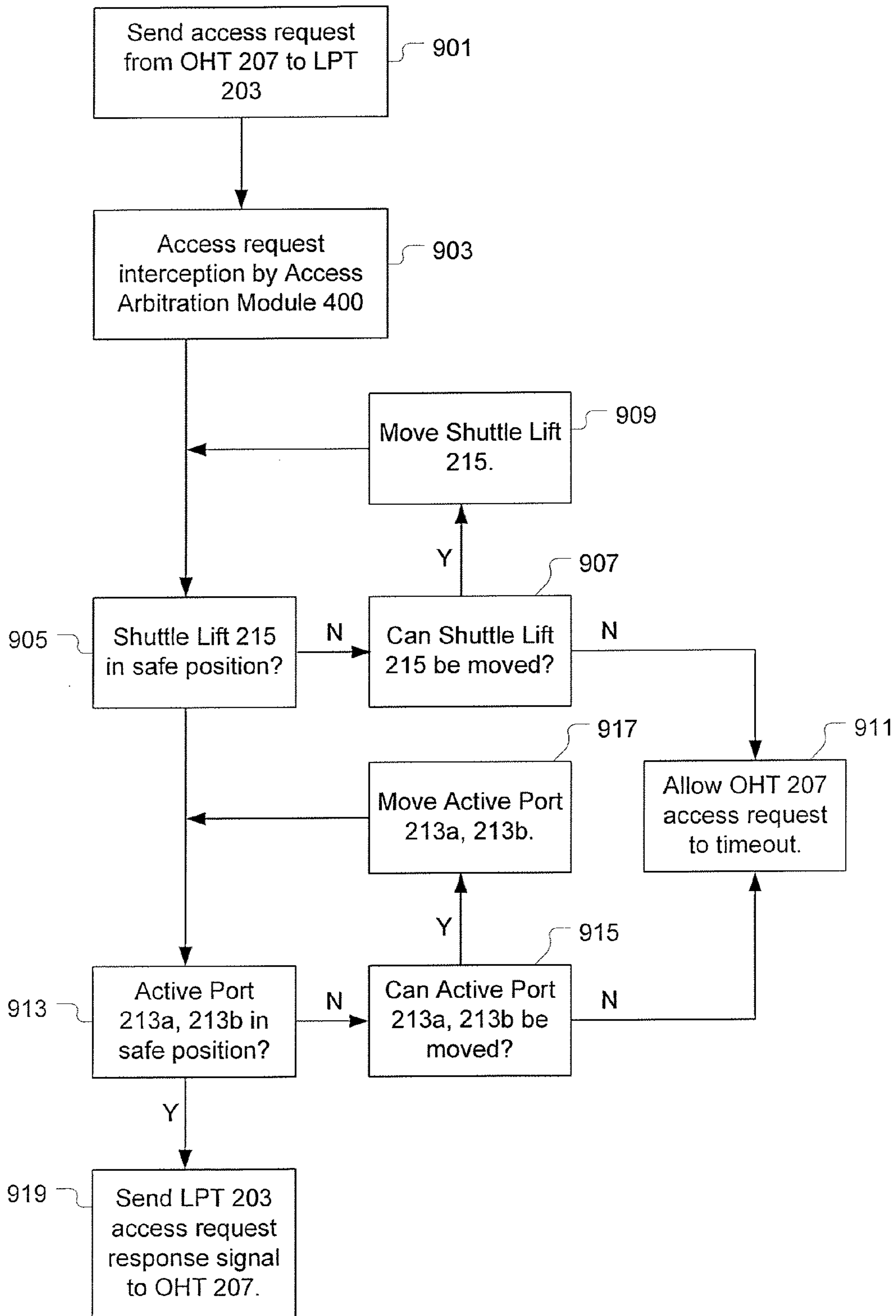


Fig. 9

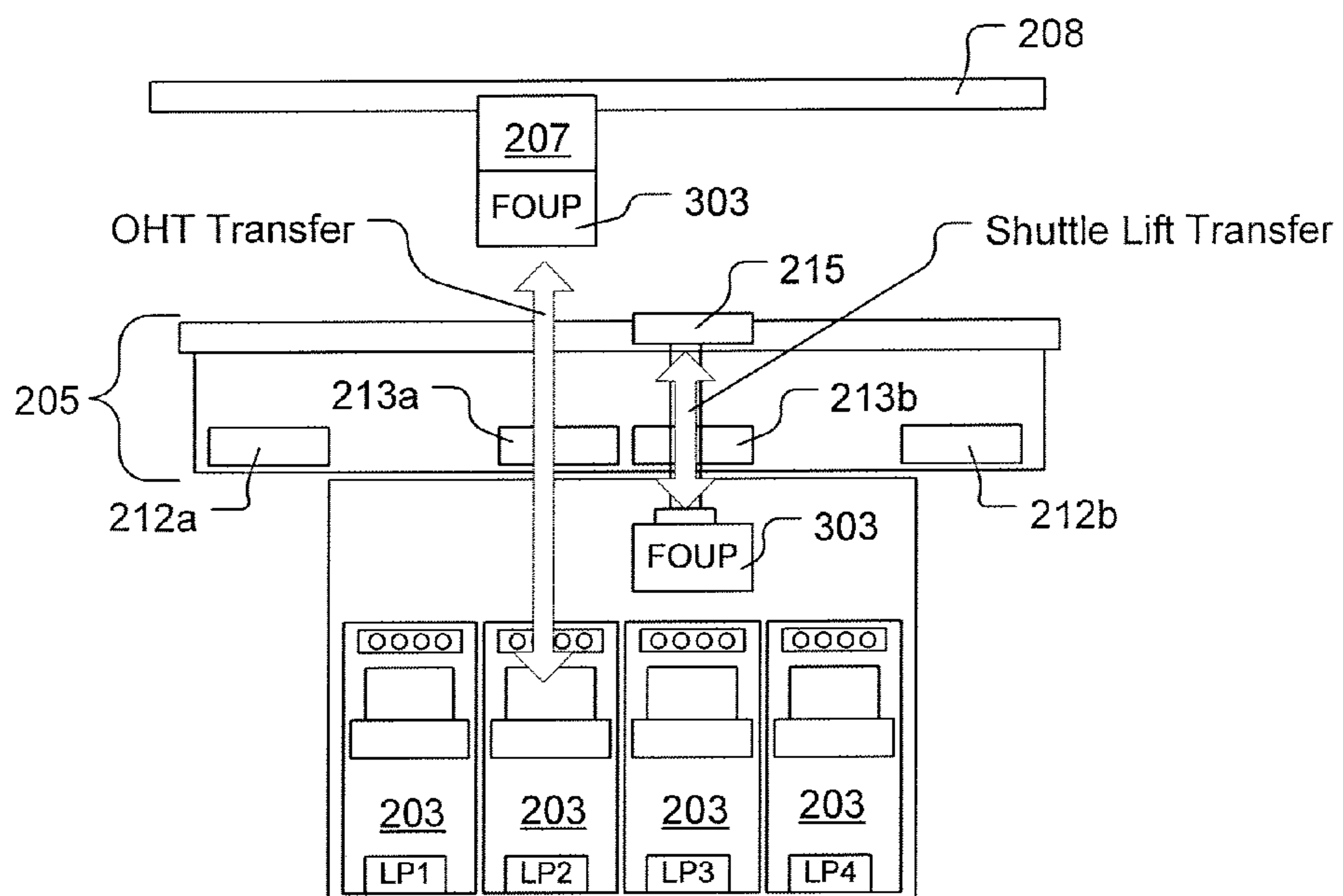


Fig. 10

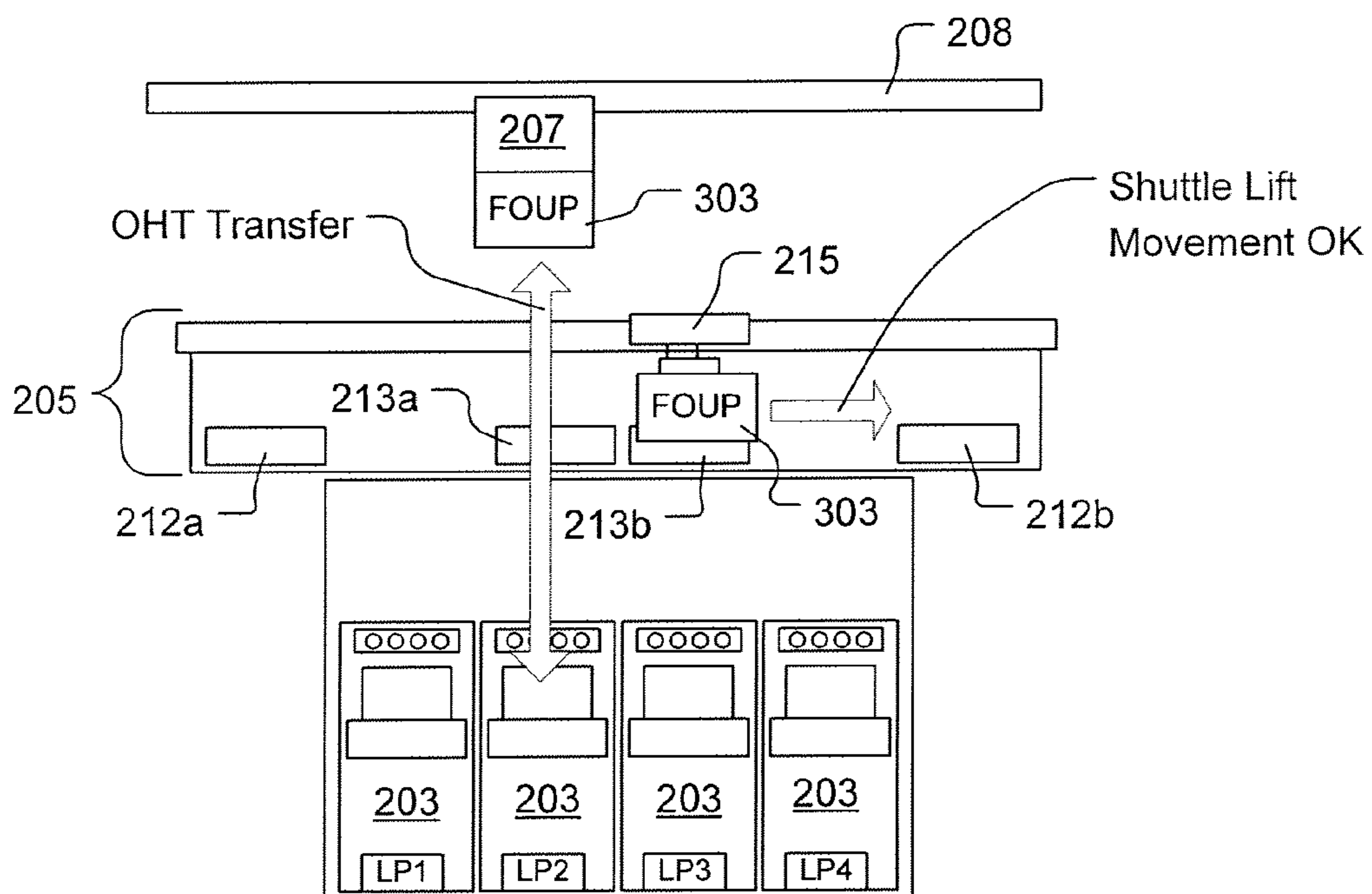


Fig. 11

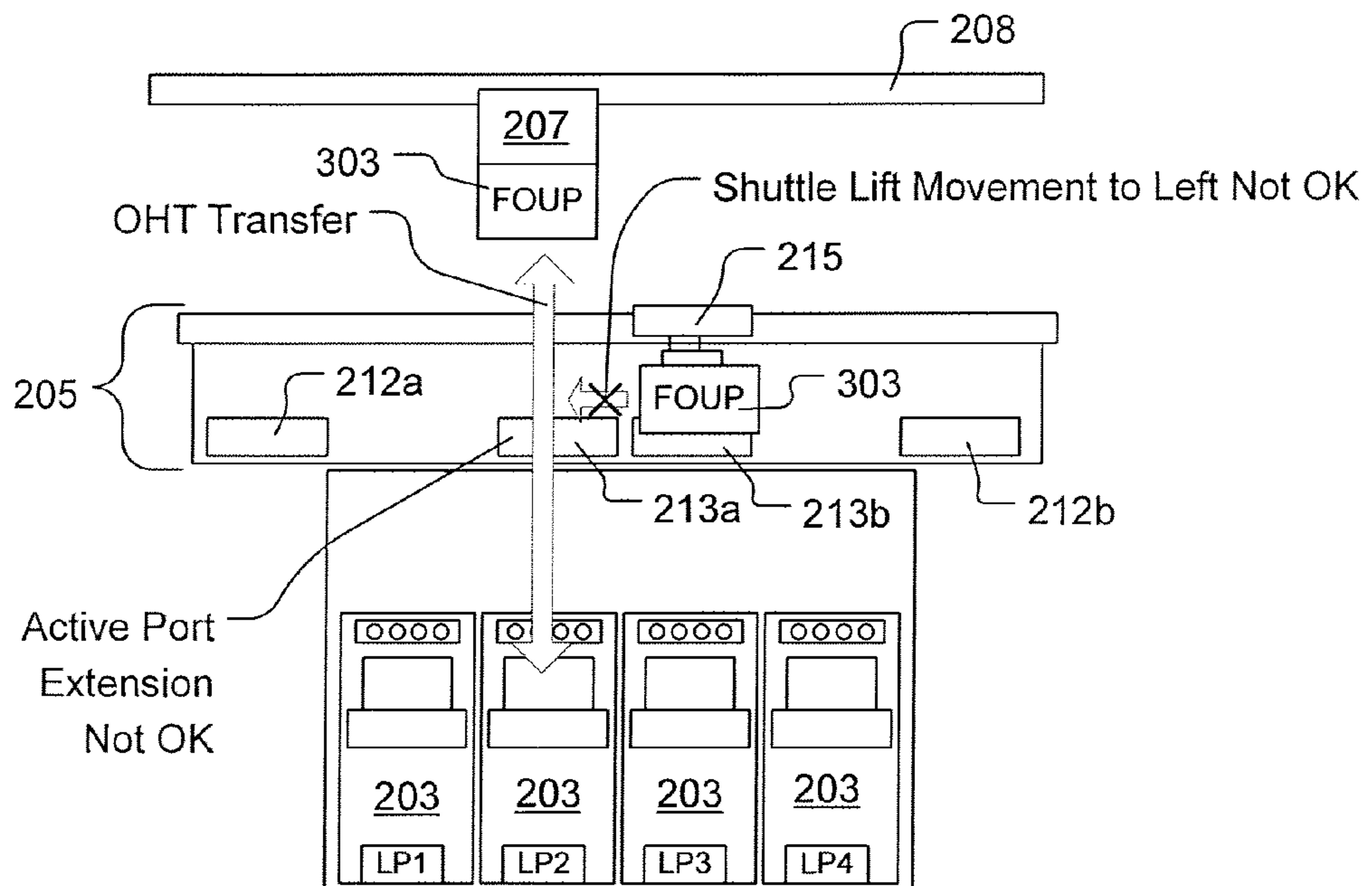


Fig. 12

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**ACCESS ARBITRATION MODULE AND
SYSTEM FOR SEMICONDUCTOR
FABRICATION EQUIPMENT AND METHODS
FOR USING AND OPERATING THE SAME**

BACKGROUND

Modern semiconductor factories use a variety of automation systems for movement of materials and control of fabrication processes. As used herein, the terms semiconductor factory and semiconductor fab are synonymous, and are respectively abbreviated as factory and fab. The various automation systems within the fab include hardware and software that are interfaced to work together to automate the movement of material, data, and control through the fab. Major automation systems in the fab may include: MES (Manufacturing Execution System), AMHS (Automated Material Handling System), MCS (Material Control System), station Control for tool connectivity, EFEMs (Equipment Front-End Modules) and loadports for interface between factory tools and the AMHS, material tracking systems like radiofrequency identifier (RFID) and barcode, and associated software products that may or may not be used in a fab and may or may not be bundled together to handle functions like fault detection, recipe management, scheduling and dispatch, statistical process control (SPC), and others. The AMHS can include sub-systems such as an OHT (overhead hoist transport) system, a near-tool container buffer system, and AGVs (automated guided vehicles). Additionally, the fab can include manually operated material handling and movement systems, such as PGVs (person guided vehicles), among others.

During semiconductor manufacturing, a semiconductor wafer undergoes a plurality of process steps, each of which are performed by a specialized process tool. Workpiece containers are used to convey semiconductor wafers from one tool to another. Each workpiece container is capable of transporting a number of wafers of a specific diameter. The workpiece containers are designed to maintain a protected internal environment to keep the wafers free of contamination, e.g., by particulates in the air outside the workpiece container. Workpiece containers are also known for conveying other types of substrates, such as reticles, liquid crystal panels, rigid magnetic media for hard disk drives, solar cells, etc.

It is an ongoing desire to improve fab logistics and productivity in the areas of cycle time, throughput, WIP (Work-in-Progress) levels, material handling, etc. Improvement in fab logistics can be of particular concern with regard to fabrication of larger wafers. For example, fabrication of 300 mm and larger wafers requires more automated transport through the fab, thereby benefiting from improved fab logistics. Also, fabrication of smaller technology node devices having decreased line widths may require more process steps, which in turn requires more automated transport through the fab and increases the complexity of cycle time control in the fab. Therefore, improvement in fab logistics can also benefit fabrication of smaller technology node devices.

FIG. 1 shows an example floorplan 101 of a portion of a fab. The floorplan includes a many different fabrication process and/or metrology tools 103A-103L. The fabrication tools can include essentially any type of semiconductor wafer fabrication tool, including but not limited to, wafer plasma processing tools for material etching and/or deposition, wafer cleaning tools, wafer rinsing tools, wafer planarization tools, among others. The floorplan can also include material handling equipment, including but not limited to, lifters/elevators, OHT (overhead hoist transport) systems, OHV's (over-

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head hoist vehicles), RGV's (rail-guided vehicles), floor conveyers, STC's (material storage/stockers), among others. The floorplan of FIG. 1 shows example travel routes 105 of material handling systems, such as the OHT system, the RGV system, and/or floor conveyers, among others. The floorplan of FIG. 1 also shows a number of material transport vehicles 107, such as OHV's, RGV's, among others, traveling along the various travel routes 105 to move workpiece containers carrying semiconductor wafers or other types of workpieces.

It should be understood that there is an essentially limitless number of floorplan variations possible with a given fab. For example, different fabs can include different combination of process and/or metrology tools. Also, different fabs can include different material handling systems and associated routes. However, what most fabs share is a need to accurately and reliably move workpieces between locations in a most efficient manner as possible. The OHT, RGV, AGV, PGV, and floor conveyer systems, among others, provide a substantial ability to move workpiece containers between locations within a fab. Additionally, the near-tool workpiece container buffering capability provided by the near-tool container buffer system allows for improved management of workpiece container movement and readiness within the fab.

Conventionally, access by the various AMHS sub-systems to certain stations within the fab, such as loadports, has been necessarily restricted to ensure that the various AMHS sub-systems do not collide or interfere with each other in accessing a given station within the fab at a given time. However, while implementation of such access restrictions on the various AMHS sub-systems is effective in avoiding interference conditions within the fab, implementation of such access restrictions on the various AMHS sub-systems can inefficiencies in workpiece container handling within the fab and corresponding reductions in workpiece throughput from the fab. It is within this context of improving AMHS access management that the present invention arises.

SUMMARY

In one embodiment, an access arbitration module for a passive component within a semiconductor fabrication facility is disclosed. The access arbitration module includes a plurality of active component communication ports for communicating with a plurality of active components. The access arbitration module also includes a passive component communication port for communicating with a passive component. The access arbitration module further includes switching logic defined to control transmission of access communication protocol signals between each of the plurality of active component communication ports and the passive component communication port, such that an authorized one of the plurality of active component communication ports is connected in communication with the passive component communication port at a given time, and such that non-authorized ones of the plurality of active component communication ports are prevented from communication with the passive component communication port at the given time.

In another embodiment, a system is disclosed to include a loadport for a semiconductor fabrication tool, a first active component, a second active component, and an access arbitration module. Each of the first and second active components is defined to deliver a workpiece container to the loadport. The access arbitration module is defined to communicate with each of the loadport, the first active component, and the second active component. The access arbitration module is defined to control transmission of access communication protocol signals between each of the first and

second active components and the loadport, such that an authorized one of the first and second active components is allowed to access the loadport at a given time, and such that a non-authorized one of the first and second active components is prevented from accessing the loadport at the given time.

In another embodiment, a method is disclosed for controlling access to a loadport of a semiconductor fabrication tool. The method includes transmitting a first access protocol signal from a first active component to the loadport. The method also includes transmitting a second access protocol signal from a second active component to the loadport. The method also includes intercepting the first and second access protocol signals before they arrive at the loadport. The method also includes determining which of the first and second active components is currently authorized to access the loadport. The method also includes transmitting the intercepted first access protocol signal through to the loadport and blocking the intercepted second access protocol from transmission to the loadport, when the first active component is authorized to access the loadport. The method also includes transmitting the intercepted second access protocol signal through to the loadport and blocking the intercepted first access protocol from transmission to the loadport, when the second active component is authorized to access the loadport.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an example floorplan 101 of a portion of a fab.

FIG. 2 shows a portion of a fab in which a tool 201 is provided with four loadports LP's) 203, in accordance with one embodiment of the present invention.

FIG. 3A shows an articulation schematic of each LP 203 having a window 302 through which a container 303 is moved.

FIG. 3B shows the LP 203 configured to interface with the container 303, defined as a FOUP by way of example.

FIG. 4 shows an access arbitration module 400 defined to control access to a passive component 403 by a plurality of active components 401A-401n, in accordance with one embodiment of the present invention.

FIG. 5 shows the access arbitration module 400 with multiple passive components 403A-403n connected to the access arbitration module 400 through respective communication links 405A-405n, in accordance with one embodiment of the present invention.

FIG. 6 shows an example architectural view of the access arbitration module 400, in accordance with one embodiment of the present invention.

FIG. 7 shows an overall block diagram of the PC104 interface CPLD 611 in the example access arbitration module 400 of FIG. 6, in accordance with one embodiment of the present invention.

FIG. 8 shows an overall block diagram of each switch CPLD 619A-619D in the example access arbitration module 400 of FIG. 6, in accordance with one embodiment of the present invention.

FIG. 9 is shows a flowchart of a method by which the access arbitration module 400 operates to ensure that the near-tool container buffer system 205 components are in a safe position for OHT 207 access to the LP 203, in accordance with one embodiment of the present invention.

FIG. 10 shows an instance in which the OHT 207 is actively transferring a container to/from LP 203 (LP2), while the shuttle lift 215 is actively transferring a container to/from LP 203 (LP3) that is positioned next to LP 203 (LP2).

FIG. 11 shows another example instance in which the OHT 207 is actively transferring a container to/from LP 203 (LP2),

while the shuttle lift 215 is moving a container within the near-tool container buffer system 205 in a direction away from the vertical space through which the OHT 207 is accessing the LP 203 (LP2).

FIG. 12 demonstrates how movements of the shuttle lift 215 and active port 213a are restricted when the OHT 207 is accessing the LP 203 (LP2).

DETAILED DESCRIPTION

In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be apparent, however, to one skilled in the art that the present invention may be practiced without some or all of these specific details. In other instances, well known process operations have not been described in detail in order not to unnecessarily obscure the present invention.

An access arbitration module and system is described herein to efficiently manage potentially contentious access by AMHS sub-systems to various components within the fab. For ease of description, the access arbitration module and system is described herein with regard to managing access to loadports by two AMHS sub-systems, including the OHT (overhead hoist transport) system and the near-tool container buffer system. However, it should be understood that the access arbitration module and system as disclosed herein is not limited to use with OHT, near-tool container buffer system, and loadports. More specifically, the access arbitration module and system disclosed herein can be implemented to provided access management between any number of active systems and any number of passive systems within the fab, where each active system operates as an access requestor, and each passive system operates as a destination of the requested access.

It should be understood that the term "container" as used herein refers to a workpiece container for use within a fab, including but not limited to a FOUP (Front Opening Unified Pod), a FOSB (Front-Opening Shipping Box), a SMIF (Standard Mechanical Interface) pod, a SRP (Single Reticle Pod), an open substrate cassette, among many others. Also, it should be understood that the term "workpiece" as used herein can refer to a semiconductor wafer, a semiconductor substrate, a reticle, among many others. Moreover, the term "workpiece" as used herein can refer to any item that is worked upon by process and/or metrology tools within the fab. Also, although described herein by way of example within the context of a fab in which workpieces are transported in containers, it should be understood that the access arbitration module and system disclosed herein can be utilized in other manufacturing facilities in which multiple active systems compete for access to a shared passive system, such as in the case of manufacturing facilities for liquid crystal panels, rigid magnetic media, e.g., for hard disk drives, solar cells, among many others.

FIG. 2 shows a portion of a fab in which a tool 201 is provided with four loadports (LP's) 203, in accordance with one embodiment of the present invention. Each LP 203 is defined to provide a standard mechanical interface to wafer fabrication production tools (process and/or metrology tools) to enable loading/unloading of containers into/out of workpiece fabrication production tools, while ensuring protection of workpieces therein from contamination. FIG. 2 also shows a near-tool container buffer system 205 positioned above the tool 201 and LP's 203. FIG. 2 further shows an OHT 207 configured above the near-tool container buffer system 205 so as to travel over the LP's 203. It should be understood that the configuration of the tool 201, LP's 203, near-tool container

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buffer system **205**, and OHT **207** in FIG. **2** is provided by way of example to facilitate description of the access arbitration module and system herein and is not to be construed as limiting in any way to the access arbitration module and system disclosed herein. Specifically, it should be understood that the access arbitration module and system disclosed herein can be implemented with essentially any configuration of components within a fab where multiple components may compete for access to the same component at the same time. In the example of FIG. **2**, the OHT **207** and near-tool container buffer system **205** may compete for access to the same LP **203** at the same time.

FIG. **3A** shows an articulation schematic of each LP **203** having a window **302** through which a container **303** is moved. In one embodiment, the LP **203** is defined to move the container **303** through the window **302** in a Y direction, and is also defined to move the container **303** in a Z direction. FIG. **3B** shows the LP **203** configured to interface with the container **303**, defined as a FOUP by way of example. The LP **203** is attached to a front end of the process tool **201** as described, for example, with reference to FIGS. 1 and 2 of U.S. Pat. No. 6,502,869, which issued Jan. 7, 2003 to Rosenquist et al., and is incorporated herein by reference in its entirety. For purposes of description, the “front” of LP **203** faces away from the process tool **201**, i.e., faces toward the negative Y direction as indicated by coordinate axes **305**. The “front” of container **303** is the side facing the front of the LP **203**.

The LP **203** includes a tool interface **307**. In the semiconductor industry, tool interface **307** is often in conformance with an industry standard referred to as “Box Opener/Loader-to-Tool Standard Interface” (BOLTS), commonly referred to as a BOLTS interface or a BOLTS plate. Tool interface **307** includes the window **302** surrounded by a recessed shoulder **309**. The window **302** is substantially occluded by a port door **311**. The port door **311** forms a proximity seal with a boundary of the window **302** to prevent contaminants from migrating to the interior of the process tool **201**. A proximity seal provides a small amount of clearance, e.g., about 1 mm, between the parts forming the proximity seal. The small clearance of the proximity seal allows air at a higher pressure to escape from the interior of the process tool **201** and sweep away any particulates from the sealing surfaces of the proximity seal.

The LP **203** also includes an advance plate assembly **313** having an advance plate **315**. In one embodiment, registration pins (not shown) mate with corresponding slots or recesses in the bottom support **317** of container **303**, to facilitate alignment of the container **303** on the advance plate **315**. The container **303** may conform to industry standards for Front Opening Unified Pods (FOUPs) or a different standard. The advance plate assembly **313** has an actuator (not shown) that slides the advance plate **315** in the Y direction between the retracted position shown in FIG. **3B** and an advanced position that brings the container **303** into close proximity with the tool interface **307**. When the container **303** is in the advanced position, a front surface **319** of a flange **321** forms a proximity seal with the recessed shoulder **309** of tool interface **307**.

A front surface **323** of the port door **311** includes a pair of latch keys **325**. The latch keys **325** include a post that extends away from the port door **311** and is substantially perpendicular to port door **311**, and a crossbar at the distal end of the post. The crossbar extends perpendicularly to the post to form a “T” therewith. The port door **311** includes an actuator that interacts with the latch keys **325**, causing the latch keys **325** to rotate on the axis of the post. As the container **303** moves to the advanced position, the latch keys **325** are inserted into corresponding latch key receptacles (not shown) of a con-

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tainer door **327** of container **303**. The latch keys **325** are then rotated on the axis of the post, thereby interacting with a mechanism (not shown) internal to the container door **327**, causing the container door **327** latches to disengage from the flange **321** of the container **303**.

An example of a door latch assembly within a container door adapted to receive and operate with latch keys is disclosed in U.S. Pat. No. 4,995,430, entitled “Sealable Transportable Container Having Improved Latch Mechanism,” which is incorporated herein by reference in its entirety. Another example is presented in U.S. Pat. No. 6,502,869, issued on Jan. 7, 2003 to Rosenquist et al., also incorporated herein by reference in its entirety. In addition to disengaging the container door **327** from the container **303**, rotation of the latch keys **325** locks the latch keys **325** in their respective latch key receptacles, thereby coupling the container door **327** to the port door **311**. In one embodiment, the LP **203** includes two latch keys **325**, that are structurally and operationally identical to each other. Additionally, alignment pins **329** are provided to facilitate alignment between the port door **311** and the container door **327**, so that container door **327** will be sufficiently aligned to enable passage through the window **302** toward the interior of the process tool **201**.

In the LP **203**, once the container door **327** latches are disengaged from the flange **321**, the port door **311** is retracted in the horizontal direction (Y direction) by a mechanism **331**, as indicated by arrow **333**, thereby removing the container door **327** from the container **303**. Following retraction of the port door **311** (with container door **327** coupled thereto) in the horizontal direction **333**, the mechanism **331** is operated to move the port door **311** (with container door **327** coupled thereto) downward in a vertical direction (Z direction), as indicated by arrow **335**, thereby clearing the window **302** to enable unobstructed access from the interior of the process tool **201** to the workpieces inside the container **303**.

With reference back to FIG. **2**, the near-tool container buffer system **205** is described in detail as “storage system **100**” in U.S. patent application Ser. No. 12/780,761, filed on May 14, 2010, entitled “Substrate Container Storage System,” which is incorporated by reference herein in its entirety. Also, the near-tool container buffer system **205** is further described in detail as “storage system **100**” in U.S. patent application Ser. No. 12/780,846, filed on May 14, 2010, entitled “Integrated Systems for Interfacing with Substrate Container Storage Systems,” which is incorporated by reference herein in its entirety.

The near-tool container buffer system **205** includes a number of movable storage shelves **209**, each of which is each connected to a common drive mechanism to provide for controlled movement of the storage shelves **209** in a carousel-like manner around a drive track **211**. The near-tool container buffer system **205** also includes static ports **212a** and **212b** upon which a container **303** can be placed and removed by the OHT system **207**. The near-tool container buffer system **205** further includes active ports **213a** and **213b**, each of which is defined and configured to be horizontally extended and retracted, as indicated by arrow **214**. For example, active port **213a** is depicted in its retracted position, and active port **213b** is depicted in its extended position.

The active ports **213a** and **213b** are mechanisms that can be used to load a container **303** on to a storage shelf **209** and unload a container **303** from a storage shelf **209**. The active ports **213a** and **213b** include a port plate that can be moved vertically to either an upper or lower position. When retracted with their port plate in the lower position, the active ports **213a**, **213b** are cleared from the travel path of the storage shelves **209**. When the storage shelves **209** are moved to

position a container **303** over the active port **213a**, **213b**, the port plate of the active port **213a**, **213b** can be moved to its upper position, so as to engage the container **303** and lift the container **303** from the storage shelf **209**. Then, the active port **213a**, **213b** can be extended horizontally to move the container **303** away from the storage shelf **209** to a position at which the container **303** can be engaged by a shuttle lift **215** of the near-tool container buffer system **205**. It should be appreciated that the active port **213** can be operated in a reverse manner from that described above in order to move the container **303** back from the shuttle lift **215** engagement position to a storage shelf **209**.

The shuttle lift **215** is defined and configured to travel back and forth along a length of the near-tool container buffer system **205**, as indicated by arrow **217**, at a position above the static ports **212a**, **212b**, and above the active ports **213a**, **213b** in their extended position. The shuttle lift **215** is equipped with a gripper and hoist mechanism that provides for gripping of an upper handle of a container **303** and vertical movement of the container, as indicated by arrow **221**. In this manner, the shuttle lift **215** can be positioned and operated to lift containers **303** from and place containers **303** on any static port **212a**, **212b**, and extended active port **213a**, **213b**. Also, the shuttle lift **215** can be positioned and operated to lift containers **303** from and place containers **303** on the advance plate assembly **313** of any LP **203**.

Additionally, the OHT **207** can move a container **303** between stockers, storage systems and tools by way of an OHT rail **208**, as indicated by arrow **219**. Similar to the shuttle lift **215**, the OHT **207** is equipped with a gripper and hoist mechanism that provides for gripping of an upper handle of a container **303** and vertical movement of the container, as indicated by arrow **223**. In this manner, the OHT **207** can be positioned and operated to lift containers **303** from and place containers **303** on any static port **212a**, **212b**, any extended active port **213a**, **213b**, and any LP **203** advance plate assembly **313**.

Given that both the OHT **207** and near-tool container buffer system **205** shuttle lift **215** are capable of moving containers to and from each LP **203** at a given time, it should be appreciated that contention between the OHT **207** and near-tool container buffer system **205** for access to a given LP **203** at the same time must be managed to avoid collision and possible workpiece or equipment damage. Additionally, access by the OHT **207** to a given LP **203** is further complicated when the near-tool container buffer system **205** has an extendable active port **213a**, **213b** positioned over the given LP **203**, as the active port **213a**, **213b** in its extended position would block the OHT **207** hoist's vertical travel path used for movement of the container **303** to and from the given LP **203**.

Once approach to managing LP **203** access contention is to restrict the OHT **207** to movement of containers **303** to and from the static ports **212a**, **212b** of the near-tool container buffer system **205**, and utilize the shuttle lift **215** to move containers **303** between the near-tool container buffer system **205** and the LP **203**. However, while this approach can be effective in eliminating LP **203** access contention between the OHT **207** and near-tool container buffer system **205**, this approach can be inefficient for tool **201** utilization and ultimately for workpiece throughput within the fab. For instance, it is conceivable that the shuttle lift **215** may become a bottleneck to LP **203** access if the shuttle lift **215** is busy or inoperable when one or more LP's **203** are available for access. Therefore, it is of interest to allow for direct access to LP's **203** by both the OHT **207** and shuttle lift **215**. However, for this to occur, it is necessary to manage the potential LP **203** access contention between the OHT **207** and shuttle lift **215**,

as well as the potential travel path interference between the active ports **213a**, **213b** and the OHT **207**.

FIG. **4** shows an access arbitration module **400** defined to control access to a passive component **403** by a plurality of active components **401A-401n**, in accordance with one embodiment of the present invention. Each active component **401A-401n** is a component that requests access to another component, i.e., to a passive component. For example, within the context of SEMI Standard SEMI E84-1109, active components **401A-401n** correspond to active equipment, which is defined as equipment that loads/unloads a cassette onto/from the cassette stage of another piece of equipment. The passive component **403** is a component to which any active component **401A-401n** requires access. For example, within the context of SEMI Standard SEMI E84-1109, passive component **403** corresponds to passive equipment, which is defined as equipment that is loaded/unloaded by active equipment.

Each passive component provides a communication link through which an active component can communicate so as to initiate and conduct access to the passive component. This communication between active and passive components complies with a formal communication protocol to ensure proper interfacing between the active and passive components. In one embodiment, an E84 communication protocol in compliance with SEMI Standard SEMI E84-1109 is enforced between active and passive components. In this embodiment, a successful interchange between active and passive components requires that both the active and passive component follow the E84 communication protocol. If either the active or passive component fails to comply with the E84 communication protocol in establishing the interchange between the active and passive components, the interchange will not occur, and the active component will not be allowed access to the passive component. Therefore, interruption of the communication between the active and passive components provides a mechanism by which access to the passive component by the active component can be denied.

Normally, a passive component would provide a communication link to one active component, thereby avoiding possible access contention to the passive component. In other words, only the active component having access to the communication link would have access to the passive component. With implementation of the access arbitration module **400**, a communication link **405** to the passive component **403** is intercepted by the access arbitration module **400**. Also, with implementation of the access arbitration module **400**, respective communication links **407A-407n** to the plurality of active components **401A-401n** are intercepted by the access arbitration module **400**.

The access arbitration module **400** is defined to function in a multiplexer-like manner to provide controlled switching of the passive component **403** communication link **405** to only one of the communication links **407A-407n** of the active components **401A-401n** at a time, thereby restricting the communication necessary for access to the passive component **403** to only one of the plurality of active components **401A-401n** at a given time. For description purposes, the one active component **401A-401n** that is provided access to the passive component **403** at a particular time is referred to as the permitted component. Additionally, through the communication links **407A-407n** with the active components **401A-401n**, the access arbitration module **400** is defined to direct the active components **401A-401n** that are not currently provided access to the passive component **403**, i.e., that are not the permitted component, to take whatever action is necessary, if any, to avoid physical interference with the permitted component's access to the passive component **403**.

Although FIG. 4 shows the access arbitration module 400 connected to communicate with the one passive component 403, it should be understood that the access distribution module 400 can be defined to control access to any number of passive components 403 by the plurality of active components 401A-401n. FIG. 5 shows the access arbitration module 400 with multiple passive components 403A-403n connected to the access arbitration module 400 through respective communication links 405A-405n, in accordance with one embodiment of the present invention. In the embodiment of FIG. 5, the access arbitration module 400 operates to ensure that each of the multiple passive components 403 is accessible by one of the plurality of active components 401A-401n at a given time. Also, the access arbitration module 400 is defined and operated to ensure that each of the active components 401A-401n is directed to avoid interference with each permitted component's access to their target passive component 403.

With reference back to FIG. 2, it should be understood that container 303 transfers to the LP's 203 are interlocked with signals that conform to the SEMI E84 standard. The E84 standard prescribes an exchange of several signals that assure that each step of a transfer is allowed and that it is successfully completed. The E84 signals are usually transmitted through an optical link that is aligned with the active device, i.e., OHT 207 or near-tool container buffer system 205, when aligned over the LP 203. Thus, with reference to FIGS. 4 and 5, the communication links 407A-407n may be optical communication links, especially when the active component 401A-401n is defined to move relative to the passive component 403. However, it should also be understood that the E84 signals may be transmitted over a wired communication link 407A-407n when the active component 401A-401n is stationary with respect to the passive component 403. For example, because the near-tool container buffer system 205 as a whole (notwithstanding the moving components within the near-tool container buffer system 205) is stationary relative to the LP's 203 that it services, it is possible for the communication link 407A-407n between the near-tool container buffer system 205 and the access arbitration module 400 to be a wired communication link.

FIG. 6 shows an example architectural view of the access arbitration module 400, in accordance with one embodiment of the present invention. The example access arbitration module 400 of FIG. 6 is configured to include communication link inputs 613A-613D from up to four OHT 207 E84 optical communication links, and to include communication link inputs 615A-615D from up to four near-tool container buffer system 205 E84 communication links, and to include communication link inputs 617A-617D from up to four LP 203 E84 communication links. It should be understood, however, that other embodiments of the access arbitration module 400 can be defined to include essentially any number of communication link inputs from essentially any number of active devices within the fab, and include essentially any number of communication link inputs from essentially any number of passive devices within the fab. In some embodiments, the communication link inputs 613A-613D, 615A-615D, and 617A-617D are defined as DB25 interface connectors.

Structurally, the access arbitration module 400 includes an enclosure 601 with flanges 603 for mounting the access arbitration module 400 within the fab. It should be appreciated that the flanges 603 are one example of many different ways by which the access arbitration module 400 can be mounted within the fab. In one embodiment, the access arbitration module 400 is mounted to a frame of the near-tool container buffer system 205.

The access arbitration module 400 can include a computer processor 605, which may be connected to receive communication signals through a communication port 607, such as an Ethernet communication port 607. For example, the access arbitration module 400 may be connected to communicate with the fab AMHS through the communication port 607. In some embodiments, the computer processor 605 is a single board computer with a PC104 interface. The access arbitration module 400 can also include a main board in connection to the computer processor 605. In some embodiments, the main board can include a PC104 connector 609 to interface to the computer processor 605. Also, in some embodiments, the main board can include a PC104 interface CPLD (complex programmable logic device) 611 defined to manage resources on the main board, such as E84 switching, sensor inputs, and fan monitoring, among others.

Also, in some embodiments, the main board can include a number of switch CPLDs 619A-619D defined and programmed to control timing and switching of communication signals between the active device communication link inputs 613A-613D, 615A-615D, and the passive device communication link inputs 617A-617D. In the example embodiment of FIG. 6, the access arbitration module 400 include four switch CPLDs 619A-619D, each of which is connected to a different one of the communication link inputs 613A-613D of the OHT 207, and a different one of the communication link inputs 615A-615D of the near-tool container buffer system 205, and a different one of the communication link inputs 617A-617D of the LPs 203. Specifically, the switch CPLD 619A is connected to each of the communication link inputs 613A, 615A, and 617A. The switch CPLD 619B is connected to each of the communication link inputs 613B, 615B, and 617B. The switch CPLD 619C is connected to each of the communication link inputs 613C, 615C, and 617C. The switch CPLD 619D is connected to each of the communication link inputs 613D, 615D, and 617D.

In the example of FIG. 6, the switch CPLDs 619A-619D are defined to control timing and switching of E84 handshake signals between the OHT 207 or the near-tool container buffer system 205 and the LPs 203. The switch CPLDs 619A-619D are also connected to the computer processor 605 by way of the PC104 interface CPLD 611, such that computer processor 605 is able to monitor all E84 signal traffic, and such that the switch CPLDs 619A-619D are able to generate and transmit maskable state change interrupts to the computer processor 605. It should be understood that while the example embodiment of the access arbitration module 400 as described herein utilizes CPLDs 611 and 619A-619D, other embodiments of the access arbitration module 400 can be implemented using alternative circuitry and/or programming logic to provide functionality equivalent to that of the CPLDs 611 and 619A-619D.

The access arbitration module 400 also includes sensor inputs 621 from a number of near-tool container buffer system 205 position sensors. For example, the sensor inputs 621 can include a sensor input for each active port 213a, 213b to indicate whether the active port 213a, 213b is in a retracted position or extended position. Also, the sensor inputs 621 can include a number of sensor inputs to indicate a position of the shuttle lift 215. It should be understood that the sensor inputs 621 provide information as to the state of the near-tool container buffer system 205 components to enable determine as to whether or not a vertical space between the OHT 207 and a given underlying LP 203 is blocked in any way by either an active port 213a, 213b or the shuttle lift 215.

In the event that the sensor inputs 621 indicate a clear vertical space between the OHT 207 and the underlying LP

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203, the access arbitration module 400 can allow access to the underlying LP 203 by the OHT 207. In the event that the sensor inputs 621 indicate a blocked vertical space between the OHT 207 and the underlying LP 203, the access arbitration module 400 can either direct the near-tool container buffer system 205 to clear the vertical space while delaying access to the LP 203 by the OHT 207, or deny access to the LP 203 by the OHT 207. In this manner, the access arbitration module 400 is provided with sensory inputs necessary to accurately evaluate a current status of the vertical space above a given LP 203 to make decisions as to which active device can be cleared to access the given LP 203.

The access arbitration module 400 can also be equipped with an on-board AC to DC converter 623 having a AC power input 624. With its on-board power, the access arbitration module 400 can supply power to the various sensors through their respective sensor inputs 621. The access arbitration module 400 can also be equipped with a cooling fan 625. In some embodiment, the cooling fan 625 can have a tachometer output 627 connected to the computer processor 605 by way of the PC104 interface CPLD 611, such that computer processor 605 is able to monitor an operational status of the cooling fan 625.

The example access arbitration module 400 of FIG. 6 is defined to operate as an E84 multiplexer (MUX) between the OHT 207, the near-tool container buffer system 205, and the LPs 203 serviced by the near-tool container buffer system 205. In one embodiment, the example access arbitration module 400 of FIG. 6 is capable of supporting up to four LPs 203, with E84 access to each LP 203 by either the near-tool container buffer system 205 or OHT 207 on a first-come-first-serve basis.

In one embodiment, the access arbitration module 400 is programmed such that a default LP access allowance is provided to the near-tool container buffer system 205. In this embodiment, when the OHT 207 needs to access a given LP 203, the access arbitration module 400 will intercept an E84 signal (such as the E84 VALID signal, by way of example) from the OHT 207, and if the given LP 203 is ready for access and the vertical space between the OHT 207 and given LP 203 is clear, the access arbitration module 400 will connect the intercepted E84 signal through to the given LP 203 E84 communication port.

In some embodiments, the access arbitration module 400 can also be notified of an access reservation state of the given LP 203, which becomes an addition access check before the intercepted E84 signal will be transmitted through to the given LP 203 E84 communication port. For example, if a particular LP 203 is reserved for access by an OHT 207 that is on its way, another OHT 207 arriving first and requesting access to the particular LP 203 can be denied access to the particular LP 203 by the access arbitration module 400, by way of the access arbitration module 400 not transmitting the intercepted E84 signal from the first arriving OHT 207 through to the particular LP 203. In this manner, the access arbitration module 400 can be utilized to implement a look-ahead feature within the fab to provide for improved management of LPs 203 and associated fab resources.

It should be understood that OHT 207 to LP 203 access requires that the vertical space between the OHT 207 and LP 203 be clear of components that would obstruct the OHT's 207 access to the LP 203. For instance, in the OHT 207 with near-tool container buffer system 205 configuration of FIG. 2, the vertical space between the OHT 207 and LP 203 must be clear of the shuttle lift 215 and any active port 213a, 213b. However, the shuttle lift 215 and active ports 213a, 213b can be positioned at any other location outside of the vertical

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space between the OHT 207 and LP 203 that is required for OHT 207 access to the LP 203. For instance, if the OHT 207 is accessing the LP 203 through the vertical space shared by the active port 213a, the active port 213a will be fully retracted, but the active port 213b may be extended or retracted, and the shuttle lift 215 can be operating at any location other than within the vertical space through which the OHT 207 will access the LP 203. Once the container transfer between the OHT 207 and LP 203 is complete, the vertical space between the OHT 207 and LP 203 is freed for use by either the shuttle lift 215 or active port 213a, 213b.

In the event that the near-tool container buffer system 205 is down or partially disabled, separate sensors 621 between near-tool container buffer system 205 and the access arbitration module 400 will be used to determine each active port 213a, 213b and shuttle lift 215 location. This will be used to determine which OHT 207 to LP 203 vertical spaces are being blocked by the near-tool container buffer system 205 so that the blocked vertical spaces will not be switched to OHT 207 control, and corrective manual intervention may be utilized. Although mounted to the near-tool container buffer system 205, the sensors 621 are powered by and connected to the access arbitration module 400 so as not to be affected by the near-tool container buffer system 205 power status.

According to the E84 specification, the "conflict zone" is defined as being located between the OHT 207 and the LP 203. However, because the near-tool container buffer system occupies a greater volume than the LP 203, the conclusion of the "handshake" process between the OHT 207 and the LP 203 does not mean that the OHT 207 is clear of the near-tool container buffer system within the conflict zone. In one embodiment, this situation can be addressed by redefining the conflict zone of the OHT 207 as being located above the near-tool container buffer system 205. In another embodiment, this situation can be addressed by utilizing a software timer to account for the OHT 207 completely retracting above the near-tool container buffer system 205 conflict zone. This software timer can be used to determine when it is safe to move the shuttle lift 215 or active port 213a, 213b across the vertical space through which the OHT 207 was accessing the LP 203.

With the E84 specification, the TA1 timer is used by the OHT 207 to "time-out" if a L_REQ ON signal or U_REQ ON signal is not received within a specified time (typically 2 seconds) from the OHT 207 issuance of the VALID signal. If the TA1 timer expires (i.e., no L_REQ or U_REQ response signal is transmitted and received), then the OHT 207 will be forced to go around its loop of travel again. Expiration of the TA1 timer in the OHT 207 with near-tool container buffer system 205 configuration of FIG. 2 may occur because the VALID signal is not allowed to pass down from the OHT 207 to the LP 203 unless the vertical space between the OHT 207 and LP 203 is clear and the near-tool container buffer system 205 has relinquished control of the access arbitration module 400 to the OHT 207. To avoid this TA1 timer expiration, the TA1 timer can be adjusted to a longer timer duration, such as about 30 seconds by way of example. This extension of the TA1 timer will prevent needless OHT 207 loops.

In the example access arbitration module 400 embodiment of FIG. 6, there are five total CPLDs, including the PC104 interface CPLD 611, and each of the four switch CPLDs 619A-619D. However, it should be understood that in other embodiments, the access arbitration module 400 can be defined to include any number CPLDs necessary for the particular implementation. More specifically, the access arbitration module 400 can be defined to include one CPLD for the processor 605 interface and one CPLD for each passive

device connected to the access arbitration module **400** for which access is to be controlled by the access arbitration module **400**.

The PC104 interface CPLD **611** is responsible for interfacing the main board of the access arbitration module **400** to the PC104 interface **609** of the computer processor **605**. The PC104 interface CPLD **611** is defined to interpret the address and transaction on the PC104 bus and direct intended signal traffic to the resources on the main board of the access arbitration module **400**. FIG. 7 shows an overall block diagram of the PC104 interface CPLD **611** in the example access arbitration module **400** of FIG. 6, in accordance with one embodiment of the present invention. As shown in FIG. 7, the PC104 interface CPLD **611** includes 20 PC104 address lines (0-19) entering the CPLD for main address decoding.

There is an 8 bit base address configuration switch on the board, which when set is compared to the upper 8 bits of PC104 address to determine if the transaction is intended for a resource on the main board. When the upper 8 bits of PC104 address match the base address configuration switch, a global enable signal is generated that validates the processor **605** transaction to the main board. In this manner, the decode logic on the board can handle up to 4096 unique register/address locations for a variety of resources (address bits 0-11). The resources are set up as 16 blocks of 256 bytes each, accommodating 16 devices of any type which can each contain a maximum of 256 eight bit register or memory locations. In one embodiment, memory locations are "memory mapped" to the PC104 memory address space which facilitates the large number of available register/memory locations beyond the standard ISA I/O space.

The global enable signal goes to the 1 of 16 device select logic. In the example embodiment of FIG. 6, there are four switch CPLDs **619A-619D**, and internal registers within the PC104 Interface CPLD **611**. The device decode section will generate the appropriate decode/enable line to its respective switch CPLD **619A-619D**. The switch CPLDs **619A-619D** are defined to re-route E84 handshake signals between the OHT **207** or the near-tool container buffer system **205** to the LPs **203**.

The lower 8 bits of PC104 address (0-7) are passed directly to the switch CPLDs **619A-619D** for internal register selection. Eight bits of PC104 data are run into the PC104 Interface CPLD **611** for internal register write/read back, and are also passed thru to the switch CPLDs **619A-619D** for write/read back purposes. PC104 Control (for write/read purposes) route into and pass thru the CPLD **611**. The ISR & MASK registers are used to generate a maskable interrupt to the processor **605** and inform it of which specific switch CPLD **619A-619D** has generated the interrupt request. The 12 frame sensors feed this CPLD (active port retraction and shuttle position) to determine whether a given vertical space is available to the OHT **207**. Two LEDs (one green, one red) are provided for status indication. When power is applied to the access arbitration module **400**, the green LED will blink until software has initialized, at which time software turns the LED to be solid on. The red LED indicates a fault condition.

FIG. 8 shows an overall block diagram of each switch CPLD **619A-619D** in the example access arbitration module **400** of FIG. 6, in accordance with one embodiment of the present invention. The switch CPLDs **619A-619D** are defined to re-route the E84 control lines from the near-tool container buffer system **205** or the OHT **207** to the LPs **203**. The processor **605** operates to determine the appropriate time to make the switchover. Software may configure a maskable state change interrupt on any of the access arbitration module **400** active device communication link inputs **613A-613D**,

615A-615D, and passive device communication link inputs **617A-617D**. For example, an interrupt could be enabled for a state change on the E84 "VALID" signal, indicating that either the OHT **207** or the near-tool container buffer system **205** is requesting a handoff to an LP **203**. Software can field this interrupt, determine when it is safe to switch, and then write a switch bit in a control register within the corresponding switch CPLD **619A-619D** to perform the switch. In one embodiment, as a safety precaution, no changes in the switch shall be allowed by the switch CPLD **619A-619D** unless the prior transaction has concluded.

As shown in FIG. 8, each switch CPLD **619A-619D** includes a MUX element defined to route either the near-tool container buffer system **205** or OHT **207** E84 signals to a given LP **203**. Opto-isolator logic feeds this section directly, selects the source path under software control, and feeds the chosen E84 signals to the opto-isolators connected to that respective LP **203**. Each switch CPLD **619A-619D** also includes a 100 millisecond "VALID DELAY" on the leading edge of the VALID E84 signal being sent to the LP **203** to ensure E84 timing setup between CS0/CS1 and the VALID E84 signal being sent to the LP **203**. Each switch CPLD **619A-619D** also includes a selector element defined to route the LP **203** E84 signals to either the near-tool container buffer system **205** or the OHT **207**.

During normal operation of the access arbitration module **400**, both the OHT **207** and the shuttle lift **215** of the near-tool container buffer system **205** will be able to access an LP **203** for container delivery/pick-up. The access arbitration module **400** will operate to manage contention between the OHT **207** and shuttle lift **215** for access to the same LP **203**. The access arbitration module **400** will also operate to ensure that the travel trajectory of the OHT **207** for accessing the LP **203** is clear of near-tool container buffer system **205** components, including the active ports **213a**, **213b** and shuttle lift **215**. Access to the LP **203** by the OHT **207** will comply with the standard access protocol, such as the E84 protocol. Therefore, neither the LP **203** nor OHT **207** will require modification for operation with the access arbitration module **400**. Also, the access arbitration module **400** is defined to maintain electrical and mechanical characteristics of the standard access protocol, e.g., E84 protocol, as expected/required by both the LP **203** and OHT **207**, including but not limited to form fit, voltage, electrical current, and optical link isolation.

When the OHT **207** initiates access to an LP **203** for direct container transfer to the LP **203**, the access arbitration module **400** will intercept the access protocol communication signals, e.g., E84 signals, and exert control over the access request by either transmitting the access protocol communication signals through to their expected destination, or by denying transmission of the access protocol communication signals through to their expected destination, and thereby blocking the access protocol communication necessary to perform the access operation. Also, before allowing the LP **203** to respond to the OHT **207** with an appropriate access protocol communication signal, e.g., L_REQ or U_REQ, the access arbitration module **400** must ensure that the active ports **213a**, **213b** and shuttle lift **215** of the near-tool container buffer system **205** are in a safe position for OHT **207** access to the LP **203**, i.e., are clear of the vertical space between the OHT **207** and the LP **203** to be accessed. In this manner, the access arbitration module **400** ensure that no mechanical/physical interference will occur when the OHT **207** moves to transfer a container to/from the LP **203**.

FIG. 9 is shows a flowchart of a method by which the access arbitration module **400** operates to ensure that the near-tool container buffer system **205** components are in a safe position

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for OHT 207 access to the LP 203, in accordance with one embodiment of the present invention. In operation 901, the OHT 207 transmits an access request to the LP 203, such as an E84 transfer request. In operation 903, the access arbitration module 400 intercepts the access request transmitted from the OHT 207 to the LP 203. In operation 905, the access arbitration module 400 checks the sensor input signals 621 from the near-tool container buffer system 205 to determine whether or not the shuttle lift 215 is in a safe position, i.e., is out of the vertical travel path of the OHT 207 in accessing the LP 203. If the shuttle lift 215 is not in the safe position, an operation 907 is performed to determine whether or not the shuttle lift 215 can be moved to the safe position. If the shuttle lift 215 can be moved the safe position, an operation 909 is performed to move the shuttle lift 215 to the safe position. Then, the method reverts back to operation 905. If the shuttle lift 215 cannot be moved to the safe position, an operation 911 is performed to allow the OHT 207 access request to timeout, e.g., by allowing the TA1 timeout clock to run out.

With reference back to operation 905, if the shuttle lift 215 is in the safe position, an operation 913 is performed to determine whether or not the relevant active port 213a, 213b is in a safe position, i.e., is out of the vertical travel path of the OHT 207 in accessing the LP 203. If the relevant active port 213a, 213b is not in the safe position, an operation 915 is performed to determine whether or not the relevant active port 213a, 213b can be moved to the safe position. If the relevant active port 213a, 213b can be moved to the safe position; an operation 917 is performed to move the relevant active port 213a, 213b to the safe position. Then, the method reverts back to operation 913. If the relevant active port 213a, 213b cannot be moved to the safe position, the operation 911 is performed to allow the OHT 207 access request to timeout, e.g., by allowing the TA1 timeout clock to run out. With reference back to operation 913, if the relevant active port 213a, 213b is in the safe position, the method proceeds with an operation 919 in which the access arbitration module 400 operates to transmit the required LP 203 access request response to the OHT 207, such that the OHT 207 and LP 203 can proceed with the container transfer operation.

In one embodiment, the access arbitration module 400 is defined to avoid simultaneous access by the shuttle lift 215 and OHT 207 to the same LP 203, when operating under the first-come-first-serve basis. If a container transfer operation between the OHT 207 and LP 203 is initiated, the shuttle lift 215 will not be permitted to access the LP 203 being accessed by the OHT 207. Similarly, if a container transfer operation between the shuttle lift 215 and LP 203 is initiated, the OHT 207 will not be permitted to access the LP 203 being accessed by the shuttle lift 215.

It should be understood that the access arbitration module 400 is programmed to allow for simultaneous movements of the shuttle lift 215, active ports 213a, 213b, and OHT 207 whenever and wherever possible. For example, FIG. 10 shows an instance in which the OHT 207 is actively transferring a container to/from LP 203 (LP2), while the shuttle lift 215 is actively transferring a container to/from LP 203 (LP3) that is positioned next to LP 203 (LP2). FIG. 11 shows another example instance in which the OHT 207 is actively transferring a container to/from LP 203 (LP2), while the shuttle lift 215 is moving a container within the near-tool container buffer system 205 in a direction away from the vertical space through which the OHT 207 is accessing the LP 203 (LP2). FIG. 12 demonstrates how movements of the shuttle lift 215 and active port 213a are restricted when the OHT 207 is accessing the LP 203 (LP2). Specifically, as shown in FIG. 12, the access arbitration module 400 operates

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to prevent the shuttle lift 215 and active port 213a from traversing into the vertical space through which the OHT 207 is actively accessing the LP 203 (LP2).

In one embodiment, the access arbitration module 400 is programmed such that E84 container transfers that have already started are completed before allowing an operator to switch between operating modes, i.e., between OHT 207/near-tool container buffer system 205 standard operating mode and the OHT 207 direct access operating mode by way of the access arbitration module 400.

Based on the foregoing, it should be understood that the access arbitration module 400 provides an arbitration system to manage access to a given LP 203 at a given time by any of multiple container handling entities, i.e., active devices, within a fab. The access arbitration module 400 provides independent access control to each LP 203 at given time. The access arbitration module 400 can also be defined to communicate with a fab controller to obtain information about incoming container transport entities that may request access to a particular LP 203 and provide look-ahead management of those incoming container transport entities. Thus, the access arbitration module 400 provides a forecasting ability for container transport entity access to a given LP 203.

Also, in one embodiment, the access arbitration module 400 can be equipped with a wireless communication ability to enable direct handshake processing with OHT 207 vehicles before they arrive at the LP 203. Today, the OHT 207 vehicles communicate by way of optical sensors. However, it is contemplated that fabs may be wirelessly networked so that container transport entities within the fab can communicate wirelessly with other entities within the fab. With such wireless networking in place, it may be possible for an inbound container transport entity to communicate with the access arbitration module 400 before its arrival at the tool LP 203 to either begin the handshake process or be redirected if the tool is not available. This will allow the container transport vehicle to either proceed with its container drop off/pick up process immediately upon arrival at the tool LP 203, or be redirected and continue moving on to an alternate destination in the fab. In this embodiment, the container transport vehicle may not need to stop at the tool and perform the handshake process before being redirected to the alternate destination in the fab, thereby improving workpiece movement efficiency through the fab.

It should be understood that any active device within the fab that has a communication link to a passive device in the fab can be made subject to access control by way of the access arbitration module 400 intercepting the communication link. The access arbitration module 400 can interrupt any one or more required container transfer signals between the active and passive devices to enforce arbitration control. Also, it should be appreciated that the access arbitration modules 400 can be networked together. Also, the access arbitration modules 400 can be cascaded within the fab by connecting an access arbitration module 400 as an active device to another access arbitration module 400. Additionally, it should be understood that the access arbitration module 400 can be extended to accommodate any number of active devices and passive devices within the fab.

The access arbitration module 400 represents an N×N Tool LP 203 E84 switch with collision avoidance and monitoring capability. The access arbitration module 400 can be positioned as part of the near-tool container buffer system 205, but is defined independent from the near-tool container buffer system 205. The access arbitration module 400 enable both the OHT 207 and shuttle lift 215 to drop off to LPs 203. The access arbitration module 400 can operate with the near-tool

container buffer system 205 powered on, powered off, or in maintenance mode. Therefore, access by the OHT 207 to the LP 203 is not dependent on the availability of the near-tool container buffer system 205.

As discussed above, the access arbitration module 400 has 5 dedicated sensors to detect the state of the near-tool container buffer system 205, so as to avoid collisions between the OHT 207 and the shuttle lift 215 and active ports 213a, 213b of the near-tool container buffer system 205. The processor 605 on board the access arbitration module 400 is capable of com- 10 municating with the near-tool container buffer system 205, the MCS Host, and the tool 201, by way of the Ethernet connection 607. In one embodiment, such as that shown in FIG. 6, the access arbitration module 400 includes twelve E84 connections (four near-tool container buffer system-to-pas- 15 sive connections, four LP 203-to-active connections, and four OHT 207-to-passive connections). The CPLDs 611 and 619A-619D control all E84 switching operations. The access arbitration module 400 is independently powered and includes powered sensor inputs 621 for EMO, active port 20 213a, 213b position state, and shuttle lift 215 position state.

The access arbitration module 400 allows OHTs 207 to transfer containers 303 to both the near-tool container buffer system and tool LPs 203 simultaneously. The access arbitra- 25 tion module 400 also provides an ability to manage OHT 207 traffic by tapping/intercepting the near-tool container buffer system 205, LP 203, and OHT 207 signals. The access arbitration module 400 can be programmed to manage incoming OHT 207 vehicles through the fab controller (MES/MCS) before they arrive at the LP 203 location. Also, in one embodi- 30 ment, if an LP 203 is not available, the access arbitration module 400 can be programmed to allow the OHT 207 to drop off its container to the near-tool container buffer system 205 buffer, thus reducing OHT 207 congestion.

The access arbitration module 400 is scalable across mul- 35 tiple tools 201 and near-tool container buffer systems 205. The access arbitration module 400 allows for the addition of a wireless feature to directly handshake with OHT 207 vehicles before they arrive at the LP 203 tool 201. In this manner, the access arbitration module 400 enables a “look- 40 ahead” feature to start the handshake communication process between OHTs 207 and LPs 203/near-tool container buffer system 205 before the OHT 207 vehicle arrives.

While this invention has been described in terms of several 45 embodiments, it will be appreciated that those skilled in the art upon reading the preceding specifications and studying the drawings will realize various alterations, additions, permuta- tions and equivalents thereof. Therefore, it is intended that the present invention includes all such alterations, additions, per- 50 mutations, and equivalents as fall within the true spirit and scope of the invention.

What is claimed is:

1. An access arbitration module for a passive component within a semiconductor fabrication facility, comprising:

- a plurality of active component communication ports for 55 communicating with a plurality of active components, wherein each of the plurality of active components is defined to handle one or more containers within the semiconductor fabrication facility, wherein each of the one or more containers is defined to hold at least one 60 workpiece;
- a passive component communication port for communicat- ing with a passive component, the passive component defined to receive at least one container from any of the plurality of active components; and 65
- switching circuitry defined to control transmission of access communication protocol signals between each of

the plurality of active component communication ports and the passive component communication port, the switching circuitry defined to direct transmission of access communication protocol signals from one of the plurality of active component communication ports to the passive component communication port at a given time while blocking transmission of access communica- tion protocol signals from others of the plurality of active component communication ports at the given time, such that one of the plurality of active components is allowed to access the passive component at the given time.

2. The access arbitration module of claim 1, wherein the plurality of active components include a near-tool container buffer system and an overhead container transport system.

3. The access arbitration module of claim 2, wherein the plurality of active components further include an autonomous guided vehicle.

4. The access arbitration module of claim 1, wherein the passive component is a loadport for a semiconductor process- ing tool.

5. The access arbitration module of claim 1, wherein the access communication protocol signals comply with a SEMI E84 specification for enhanced carrier handoff parallel input/ output interface.

6. The access arbitration module of claim 1, further com- prising:

- a number of additional passive component communication ports for respectively communicating with a number of additional passive components, wherein the switching circuitry is defined to control transmission of access communication protocol signals between each of the plurality of active component communication ports and the passive component communication port and the number of additional passive component communica- 35 tion ports.

7. The access arbitration module of claim 1, wherein the switching circuitry is connected to each of the plurality of active component communication ports and the passive com- 40 ponent communication port, the switching circuitry defined to pass through access communication protocol signals from one of the active component communication ports associated with one of the plurality of active components currently authorized to access the passive component, the switching circuitry further defined to block access communica- 45 tion protocol signals from others of the active component communication ports associated with others of the plurality of active components not currently authorized to access the passive component.

8. The access arbitration module of claim 7, further com- prising:

- a computer processor, the switching circuitry connected to be controlled by signals transmitted from the computer processor.

9. The access arbitration module of claim 8, further com- prising:

- a network port connected to the computer processor for communication with processing entities within the semiconductor fabrication facility.

10. A system, comprising:

- a loadport for a semiconductor fabrication tool;
- a first active component defined to deliver a workpiece container to the loadport;
- a second active component defined to deliver a workpiece container to the loadport; and 65
- an access arbitration module defined to communicate with each of the loadport, the first active component, and the

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second active component, the access arbitration module defined to control transmission of access communication protocol signals between each of the first and second active components and the loadport, such that one of the first and second active components is allowed to access the loadport at a given time, and such that another of the first and second active components is prevented from accessing the loadport at the given time.

11. The system of claim 10, wherein the first active component is an overhead container transport system, and wherein the second active component is a near-tool container buffer system.

12. The system of claim 11, wherein the access arbitration module is mounted on the near-tool container buffering system.

13. The system of claim 10, wherein the access communication protocol signals comply with a SEMI E84 specification for enhanced carrier handoff parallel input/output interface.

14. The system of claim 10, further comprising:

a number of additional loadports, the access arbitration module defined to communicate with each of the number of additional loadports and to control transmission of access communication protocol signals between each of the first and second active components and the number of additional loadports.

15. A method for controlling access to a loadport of a semiconductor fabrication tool, comprising:

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transmitting a first access protocol signal from a first active component to the loadport;

transmitting a second access protocol signal from a second active component to the loadport;

operating an access arbitration module to intercept the first and second access protocol signals before they arrive at the loadport;

operating the access arbitration module to determine which of the first and second active components is currently granted access to access the loadport;

operating the access arbitration module to transmit the intercepted first access protocol signal through to the loadport and block the intercepted second access protocol signal from transmission to the loadport when the first active component is granted access to the loadport; and

operating the access arbitration module to transmit the intercepted second access protocol signal through to the loadport and block the intercepted first access protocol signal from transmission to the loadport when the second active component is granted access to the loadport.

16. The method of claim 15, wherein the first and second access protocol signals comply with a SEMI E84 specification for enhanced carrier handoff parallel input/output interface.

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